IRON-POWDER and FERRITE
COIL FORMS

AMIDON Associates, INC.

September 1988

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September 1988

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FERROMAGNETIC MATERIALS

This booklet deals with two classifications of Ferromagnetic materials. (1) Iron Powder Materials and (2) Ferrite Materials. There seems to be some confusion about these two classifications and they are often referred to as one in the same, but there is a difference. The Iron Powder class is made up strictly of iron powder, whereas the Ferrites are a combination of iron powder and other alloys.

Each classification is sub-divided into two groups. The two groups for the Iron Powder class are (1) Carbonyl Irons and (2) Hydrogen Reduced Irons. The two sub-groups for the Ferrite materials are (1) Nickel-Zinc and (2) Manganese-Zinc. Each group will have certain characteristics that may be more favorable than others for various applications. This will be explained later in this booklet.

The first half of this booklet is devoted to the Iron Powder class, giving core size and specifications. The latter half of the booklet is devoted to the Ferrite class.

In the past few decades, the advent of solid state has led to the need for core materials that would operate more efficiently at higher and higher frequencies. With the original thick laminated material, it was discovered that the apparent permeability decreased as the frequency was increased and at the same time core losses became prohibitive.

It was found that the use of thinner sheets of material insulated from each other would produce better results. This was primarily due to an effect called eddy current shielding. It was also found that as the frequency was increased with any given material, the depth of magnetic penetration would decrease. This progression worked toward thinner laminated alloys to meet the needs for higher frequency applications

While the thinner laminations were useful for broadband transformers, they were unable to meet the need for selective circuits where high 'Q' was required. During research to meet this need, it was found that a core with laminations in all directions was required in order to minimize losses and maintain a reliable inductance and `Q' in relation to frequency. As a result the grain oriented alloys were developed.

The CARBONYL IRON MATERIAL is a grain oriented material and has very small particles which are formed by the decomposition of penta-carbonyl iron vapor. This produces a spherical particle with an `onion skin' structure. The laminating affect of the `onion skin' structure produces a resistivity of the individual particles which is much higher than that of pure iron. This high resistance in conjunction with the very small particle size greatly enhances the high frequency performance.

The CARBONYL IRON CORES can be manufactured to a very tight tolerance and will remain extremely stable with frequency change, temperature change, and a variable applied signal level. All of these are important considerations in high 'Q' selective circuits. The Carbonyl Iron Material can produce cores with permeabilities ranging from 3 to 35 mu. and are very useful for resonant circuits where stability is essential. Because of the high saturation point of the Carbonyl Iron cores, they are also very useful for higher power RF circuits.

HYDROGEN REDUCED IRON material has relatively large particle size and low resistance This type of material can produce cores with higher permeabilities from 35 to 90 mu. The losses are very low at low frequency but increase significantly as the frequency increases. Cores produced from this type of material are commonly used for differential-mode chokes in line filters and DC output chokes in switching power supplies.

IRON POWDER CORES in general are especially suited for Hi-Q, high frequency circuits where environmental and electrical conditions are subject to constant change, especially those from the Carbonyl Iron group. In many cases good stability may be more important than high permeability and Iron Powder cores can satisfy this requirement.

FERRITE MATERIAL was developed in the 1930^{s}. It can produce cores with higher permeability than can be obtained with Iron Powder cores. This is a distinct advantage in transformer design and other cases where high inductance is the prime factor rather than high `Q'. Fewer turns will be needed resulting in smaller component size. Ferrite Materials are also sub-divided into two further groups, (1) Nickel-Zinc, and (2) Manganese-Zinc.

NICKEL-ZINC FERRITE CORES have a permeability range from 20 to 850 mu. These cores are useful for high frequency resonant circuits and will provide a good `Q'. Because of their high mu, fewer turns will be required for a given inductance.

MANGANESE-ZINC FERRITE CORES offer a permeability range from 850 to more than 5000 mu. They are especially useful when high inductance is required and also for RF attenuation. For further information and core specifications, see Ferrite section in the latter half of this booklet.

TOROIDAL CORES IN GENERAL are the most efficient of any core configuration. They are highly self shielding since most of the lines of flux are contained within the toroidal form. The flux lines are essentially uniform over the entire magnetic path length and consequently stray magnetic fields will have very little effect, if any, on a toroidal inductor. It is seldom necessary to shield a toroidal core to prevent feedback or cross-talk.

Iron Powder Cores

Iron Powder Cores are made in numerous shapes and sizes: such as Toroidal Cores, E-cores, Shielded Coil Forms, Sleeves etc., each of which are available in many different materials. There are two basic groups of iron powder material: (1) The Carbonyl Iron and, (2) The Hydrogen Reduced Iron.

The Carbonyl Iron cores are especially noted for their stability over a wide range of temperatures and flux levels. Their permeability range is from less than 3 mu to 35 mu and can offer excellent 'Q' factors from 50 KHz to 200 MHz. They are ideally suited for a variety of RF applications where good stability and good 'Q' are essential. Also, they very much in demand for broadband inductors, especially where high power is concerned.

The Hydrogen Reduced Iron cores have higher permeabilities ranging from 35 mu to 90 mu. Somewhat lower 'Q' can be expected from this group of cores. They are mainly used for EMI filters and low frequency chokes. They are also very much in demand for input and output filters for switched mode power supplies.

The next several pages are devoted to iron powder materials and the toroidal core configuration in particular, showing physical dimensions of available items, their A_L values and other magnetic properties, as well as how to select the proper core for your application.

In general, toroidal cores are the most efficient of any core configuration. They are highly self-shielding since most of the flux lines are contained within the core. The flux lines are essentially uniform over the entire length of the magnetic path and consequently stray magnetic fields will have very little effect on a toroidal inductor. It is seldom necessary to shield a toroidal inductor.

The A_L value of each iron powder core will be found in the charts on the next several pages. Use this A_L value and the formula found at the end of the charts to calculate the number of turns needed for your application.

Iron Powder Materials

MATERIAL #0 (u=1) Most commonly used for frequencies above 100 MHz. Available in toroidal form only

MATERIAL #1 (u=20) A Carbonyl 'C' material very similar to material #3 except that it has higher volume resistivity and better stability. Available in toroidal form and shielded coil form.

MATERIAL #2 (u=10) A Carbonyl 'E' iron powder material having high volume resistivity. Offers high 'Q' for the 2 MHz to 30 MHz. frequency range. Available in toroidal form and shielded coil form.

MATERIAL #3 (u=35) A carbonyl 'HP' material having excellent stability and good 'Q' for the lower frequencies from 50 KHz. to 500 KHz. Available in toroidal form and shielded coil form.

MATERIAL #6 (u=8) A carbonyl 'SF' material very similar to #2 material but has an improved 'Q'. Frequency range 20 MHz to 50 MHz. Available in both toroidal form and shielded coil form.

MATERIAL #10 (u=6) A powdered iron 'W' material. Offers good good 'Q' and high stability for frequencies 40 MHz to 100 MHz. Available in toroidal form and shielded coil form.

MATERIAL #12 (u=4) A synthetic oxide material which can provide good 'Q' and moderate stability for frequencies from 50 MHz to 200 MHz. If high 'Q' is of prime importance this material is a good choice. If stability is of a prime importance consider the #17 material. The #12 material is available in all sizes up to T-94 in toroidal form. Not available in shielded coil form.

MATERIAL #15 (u=25) A carbonyl 'GS6' material. Has excellent stability and good 'Q'. A good choice for commercial broadcast frequencies where good 'Q' and stability are essential. Available in toroidal form only.

Material #17 (u=4) This is a new carbonyl material which is practically the same as the #12 material except that it has better temperature stability. However, as compared to the #12 material, there will be a slight loss of 'Q' of about 10 % from 50 to 100 MHz. Above 100 MHz the 'Q' will gradually deteriorate to approximately 20% lower. In toroidal form this material is available only in sizes from T-12 to T-50. It is available in all shielded coil forms.

MATERIAL #26 (u=75) A Hydrogen Reduced material. Has highest permeability of all of the iron powder materials. Used for EMI filters and DC chokes. The #26 is very similar to the older #41 material but can provide an extended frequency range. Available in toroidal cores only.

IRON POWDER TOROIDAL CORES
For Resonant Circuits

MATERIAL 0 Perm. 1 Freq. Range 100 MHz - 300 MHz Color -tan

Core number \/	O.D. (inches)	I.D. (inches)	Hgt. (inches)	ℓ_e (cm)	A_e $(cm)^2$	V_e $(cm)^3$	A_L Value uh/100 turns
T-12-0	.125	.062	.050	0.74	.010	.007	3.0
T-16-0	.160	.078	.060	0.95	.016	.015	3.0
T-20-0	.200	.088	.070	1.15	.025	.029	3.5
T-25-0	.255	.120	.096	1.50	.042	.063	4.5
T-30-0	.307	.151	.128	1.83	.065	.119	6.0
T-37-0	.375	.205	.128	2.32	.070	.162	4.9
T-44-0	.440	.229	.159	2.67	.107	.286	6.5
T-50-0	.500	.303	.190	3.03	.121	.367	6.4
T-68-0	.690	.370	.190	4.24	.196	.831	7.5
T-80-0	.795	.495	.250	5.15	.242	1.246	8.5
T-94-0	.942	.560	.312	6.00	.385	2.310	10.6
T-106-0	1.060	.570	.437	6.50	.690	4.485	19.0
T-130-0	1.300	.780	.437	8.29	.730	6.052	15.0

MATERIAL 1 Perm 20 Freq. Range 0.5 MHz- 5. MHz Color - Blue

Core number \/	O.D. (inches)	I.D. (inches)	Hgt. (inches)	ℓ_e (cm)	A_e $(cm)^2$	V_e $(cm)^3$	A_L Value uh/100 turns
T-12-1	.125	.062	.050	0.74	.010	.007	48
T-16-1	.160	.078	.060	0.95	.016	.015	44
T-20-1	.200	.088	.070	1.15	.025	.029	52
T-25-1	.255	.120	.096	1.50	.042	.063	70
T-30-1	.307	.151	.128	1.83	.065	.119	85
T-37-1	.375	.205	.128	2.32	.070	.162	80
T-44-1	.440	.229	.159	2.67	.107	.286	105
T-50-1	.500	.303	.190	3.03	.121	.367	100
T-68-1	.690	.370	.190	4.24	.196	.831	115
T-80-1	.795	.495	.250	5.15	.242	1.246	115
T-94-1	.942	.560	.312	6.00	.385	2.310	160
T-106-1	1.060	.570	.437	6.50	.690	4.485	325
T-130-1	1.300	.780	.437	8.29	.730	6.052	200
T-157-1	1.570	.950	.570	10.05	1.140	11.457	320
T-184-1	1.840	.950	.710	11.12	2.040	22.685	500
T-200-1	2.000	1.250	.550	12.97	1.330	17.250	250

Note: All materials can be very useful well below the lower frequency limit shown above.

IRON POWDER TOROIDAL CORES
For Resonant Circuits

MATERIAL 2 Perm. 10 Freq. Range 2 MHz - 30 MHz Color Red

Core number \/	O.D. (inches)	I.D. (inches)	Hgt. (inches)	ℓ_e (cm)	A_e $(cm)^2$	V_e $(cm)^3$	A_L Value uh/100 turns
T-12-2	.125	.062	.050	0.74	.010	.007	20
T-16-2	.160	.078	.060	0.95	.016	.015	22
T-20-2	.200	.088	.070	1.15	.025	.029	25
T-25-2	.255	.120	.096	1.50	.042	.063	34
T-30-2	.307	.151	.128	1.83	.065	.119	43
T-37-2	.375	.205	.128	2.32	.070	.162	40
T-44-2	.440	.229	.159	2.67	.107	.286	52
T-50-2	.500	.303	.190	3.03	.121	.367	49
T-68-2	.690	.370	.190	4.24	.196	.831	57
T-80-2	.795	.495	.250	5.15	.242	1.246	55
T-94-2	.942	.560	.312	6.00	.385	2.310	84
T-106-2	1.060	.570	.437	6.50	.690	4.485	135
T-130-2	1.300	.780	.437	8.29	.730	6.052	110
T-157-2	1.570	.950	.570	10.05	1.140	11.457	140
T-184-2	1.840	.950	.710	11.12	2.040	22.685	240
T-200-2	2.000	1.250	.550	12.97	1.330	17.250	120
T-200A-2	2.000	1.250	1.000	12.97	2.240	29.050	218
T-225 -2	2.250	1.405	.550	14.56	1.508	21.956	120
T-225A-2	2.250	1.485	1.000	14.56	2.730	39.749	215
T-300 -2	3.058	1.925	.500	19.83	1.810	35.892	114
T-300A-2	3.048	1.925	1.000	19.83	3.580	70.991	228
T-400 -2	4.000	2.250	.650	24.93	3.660	91.244	180
T-400A-2	4.000	2.250	1.300	24.93	7.432	185.280	360
T-520 -2	5.200	3.080	.800	33.16	5.460	181.000	207

MATERIAL 3 Perm 35 Freq. Range .05 MHz - .5 MHz Color - Gray

Core number \/	O.D. (inches)	I.D. (inches)	Hgt. (inches)	ℓ_e (cm)	A_e $(cm)^2$	V_e $(cm)^3$	A_L Value uh/100 turns
T-12-3	.125	.062	.050	0.74	.010	.007	60
T-16-3	.160	.078	.060	0.95	.016	.015	61
T-20-3	.200	.088	.070	1.15	.025	.029	76
T-25-3	.255	.120	.096	1.50	.042	.063	100
T-30-3	.307	.151	.128	1.83	.065	.119	140
T-37-3	.375	.205	.128	2.32	.070	.162	120
T-44-3	.440	.229	.159	2.67	.107	.286	180
T-50-3	.500	.303	.190	3.03	.121	.367	175
T-68-3	.690	.370	.190	4.24	.196	.831	195
T-80-3	.795	.495	.250	5.15	.242	1.246	180
T-94-3	.942	.560	.312	6.00	.385	2.310	248
T-106-3	1.060	.570	.437	6.50	.690	4.485	450
T-130-3	1.300	.780	.437	8.29	.730	6.052	350
T-157-3	1.570	.950	.570	10.05	1.140	11.457	420
T-184-3	1.840	.950	.710	11.12	2.040	22.685	720
T-200-3	2.000	1.250	.550	12.97	1.330	17.250	425
T-200A-3	2.000	1.250	1.000	12.97	2.240	29.050	460
T-225 -3	2.250	1.405	.550	14.56	1.508	21.956	425

IRON POWDER TOROIDAL CORES
For Resonant Circuits

MATERIAL 6 Perm. 8 Freq. Range 10 MHz - 50 MHz Color - Yellow

Core number \/	O.D. (inches)	I.D. (inches)	Hgt. (inches)	ℓ_e (cm)	A_e $(cm)^2$	V_e $(cm)^3$	A_L Value uh/100 turns
T-12-6	.125	.062	.050	0.74	.010	.007	17
T-16-6	.160	.078	.060	0.95	.016	.015	19
T-20-6	.200	.088	.070	1.15	.025	.029	22
T-25-6	.255	.120	.096	1.50	.042	.063	27
T-30-6	.307	.151	.128	1.83	.065	.119	36
T-37-6	.375	.205	.128	2.32	.070	.162	30
T-44-6	.440	.229	.159	2.67	.107	.286	42
T-50-6	.500	.303	.190	3.03	.121	.367	46
T-68-6	.690	.370	.190	4.24	.196	.831	47
T-80-6	.795	.495	.250	5.15	.242	1.246	45
T-94-6	.942	.560	.312	6.00	.385	2.310	70
T-106-6	1.060	.570	.437	6.50	.690	4.485	116
T-130-6	1.300	.780	.437	8.29	.730	6.052	96
T-157-6	1.570	.950	.570	10.05	1.140	11.457	115
T-184-6	1.840	.950	.710	11.12	2.040	22.685	195
T-200-6	2.000	1.250	.550	12.97	1.330	17.250	100
T-200A-6	2.000	1.250	1.000	12.97	2.240	29.050	180
T-225 -6	2.250	1.405	.550	14.56	1.508	21.956	100

MATERIAL 10 Perm 6 Freq. Range 30 MHz - 100 MHz Color - Black

Core number \/	O.D. (inches)	I.D. (inches)	Hgt. (inches)	ℓ_e (cm)	A_e $(cm)^2$	V_e $(cm)^3$	A_L Value uh/100 turns
T-12-10	.125	.062	.050	0.74	.010	.007	12
T-16-10	.160	.078	.060	0.95	.016	.015	13
T-20-10	.200	.088	.070	1.15	.025	.029	16
T-25-10	.255	.120	.096	1.50	.042	.063	19
T-30-10	.307	.151	.128	1.83	.065	.119	25
T-37-10	.375	.205	.128	2.32	.070	.162	25
T-44-10	.440	.229	.159	2.67	.107	.286	33
T-50-10	.500	.303	.190	3.03	.121	.367	31
T-68-10	.690	.370	.190	4.24	.196	.831	32
T-80-10	.795	.495	.250	5.15	.242	1.246	32
T-94-10	.942	.560	.312	6.00	.385	2.310	58

All items listed in this booklet can usually be shipped immediately from stock.

IRON POWDER TOROIDAL CORES
For Resonant Circuits

MATERIAL 12 Perm 4 Freq. range 50 MHz - 200 MHz. Grn & Wh.

Core number \/	O.D. (inches)	I.D. (inches)	Hgt. (inches)	ℓ_e (cm)	A_e $(cm)^2$	V_e $(cm)^3$	A_L Value uh/100 turns
T-12-12	.125	.062	.050	0.74	.010	.007	7.5
T-16-12	.160	.078	.060	0.95	.016	.015	8.0
T-20-12	.200	.088	.070	1.15	.025	.029	10.0
T-25-12	.255	.120	.096	1.50	.042	.063	12.0
T-30-12	.307	.151	.128	1.83	.065	.119	16.0
T-37-12	.375	.205	.128	2.32	.070	.162	15.0
T-44-12	.440	.229	.159	2.67	.107	.286	18.5
T-50-12	.500	.303	.190	3.03	.121	.367	18.0
T-68-12	.690	.370	.190	4.24	.196	.831	21.0
T-80-12	.795	.495	.250	5.15	.242	1.246	22.0
T-94-12	.942	.560	.312	6.00	.385	2.310	32.0

Note: If greater stability is desired ask for #17 material, but 'Q' will be sacrificed. See material description and temperature chart. Sizes available only T-12 through T-50. Color code for material #17 - Blue and Yellow.

MATERIAL 15 Perm 25 Freq. 0.1 MHz - 2. MHz Color - Rd & Wh

Core number \/	O.D. (inches)	I.D. (inches)	Hgt. (inches)	ℓ_e (cm)	A_e $(cm)^2$	V_e $(cm)^3$	A_L Value uh/100 turns
T-12-15	.125	.062	.050	0.74	.010	.007	50
T-16-15	.160	.078	.060	0.95	.016	.015	55
T-20-15	.200	.088	.070	1.15	.025	.029	65
T-25-15	.255	.120	.096	1.50	.042	.063	85
T-30-15	.307	.151	.128	1.83	.065	.119	93
T-37-15	.375	.205	.128	2.32	.070	.162	90
T-44-15	.440	.229	.159	2.67	.107	.286	160
T-50-15	.500	.303	.190	3.03	.121	.367	135
T-68-15	.690	.370	.190	4.24	.196	.831	180
T-80-15	.795	.495	.250	5.15	.242	1.246	170
T-94-15	.942	.560	.312	6.00	.385	2.310	200
T-106-15	1.060	.570	.437	6.50	.690	4.485	345
T-130-15	1.300	.780	.437	8.29	.730	6.052	250
T-157-15	1.570	.950	.570	10.05	1.140	11.457	360

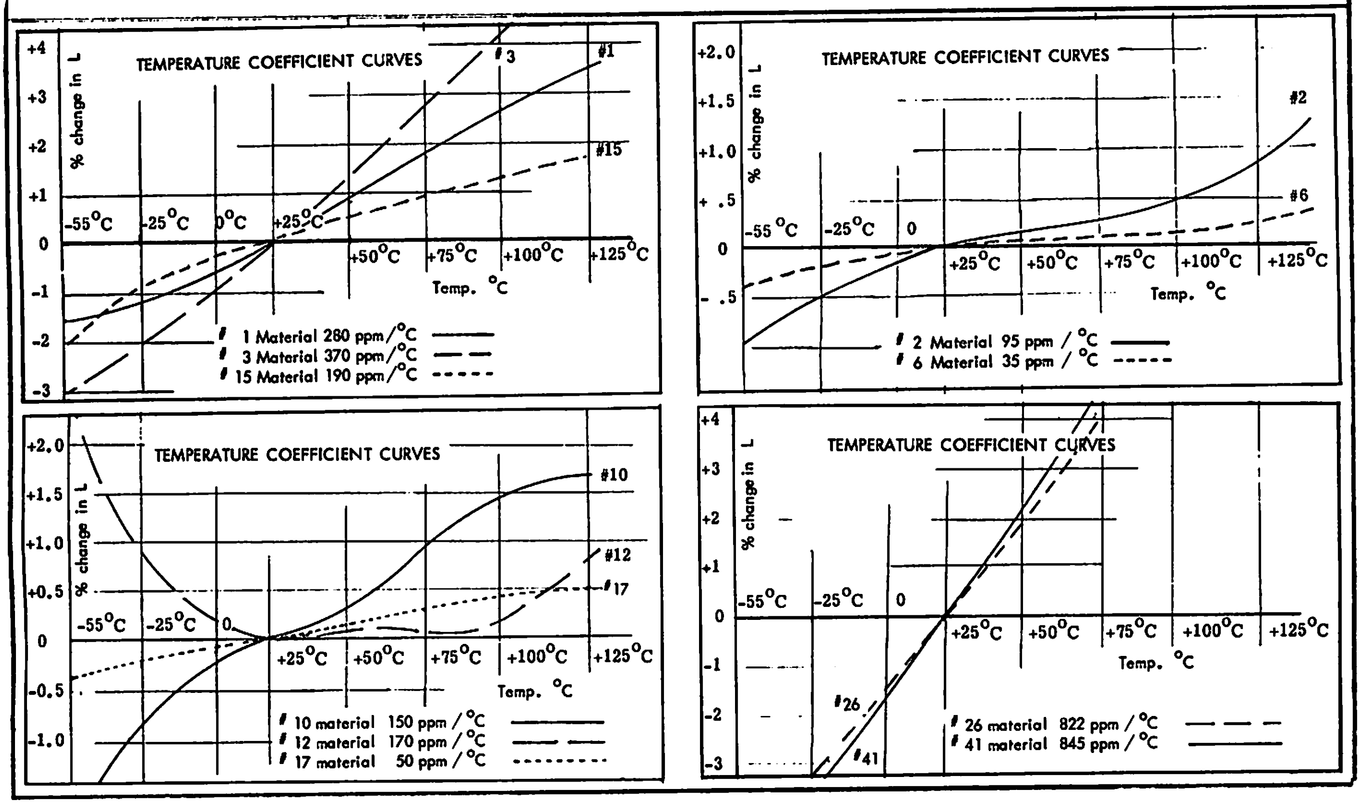
MATERIAL 26 See AC Line Filter and DC Choke section.

The following equations are useful for calculating number of turns, inductance or the A_L value of any Iron Powder toroidal core. Each core has been assigned an A_L value which will be found in the preceding Iron Powder toroidal core charts.

$$N = 100\sqrt{\frac{\text{desired 'L' (uh)}}{A_L\text{ (uh/100 turns)}}} \qquad L\text{ (uh)} = \frac{A_L \times N^2}{10{,}000} \qquad A_L\text{ (uh /100 turns)} = \frac{10{,}000 \times \text{'L' (uh)}}{N^2}$$

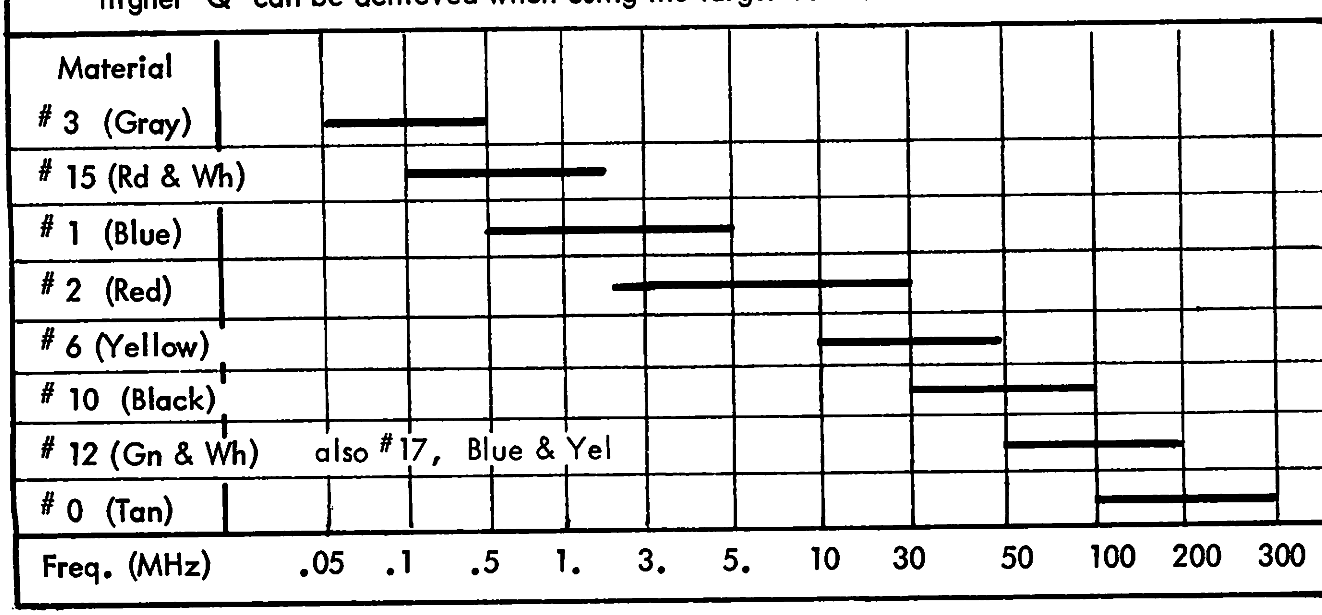
N = number of turns: L = inductance (uh) A_L = inductance index (uh / 100 turns)

TEMPERATURE COEFFICIENT CHARTS



IRON - POWDER MATERIAL vs. FREQUENCY RANGE

Higher Q will be obtained in the upper portion of a materials frequency range when smaller cores are used. Likewise, in the lower portion of a materials frequency range, higher Q can be achieved when using the larger cores.



IRON POWDER TOROIDAL CORES

Physical Dimensions

Core Size \/	Outer diam. (in)	Inner diam. (in)	Height (in)	Mean lgth. (cm)	Cross sect. (cm^2)	Core Size	Outer diam (in)	Inner diam (in)	Height (in)	Mean lgth. (cm)	Cross sect. (cm^2)
T- 12	.125	.062	.050	0.75	.010	T-130	1.30	.78	.437	8.29	0.73
T- 16	.160	.078	.060	0.95	.016	T-157	1.57	.95	.570	10.05	1.14
T- 20	.200	.088	.070	1.15	.025	T-184	1.84	.95	.710	11.12	2.04
T- 25	.250	.120	.096	1.50	.042	T-200	2.00	1.25	.550	12.97	1.33
T- 30	.307	.151	.128	1.83	.065	T-200A	2.00	1.25	1.000	12.97	2.42
T- 37	.375	.205	.128	2.32	.070	T-225	2.25	1.40	.550	14.56	1.50
T- 44	.440	.229	.159	2.67	.107	T-225A	2.25	1.40	1.000	14.56	2.73
T- 50	.500	.300	.190	3.20	.121	T-300	3.00	1.92	.500	19.83	1.81
T- 68	.690	.370	.190	4.24	.196	T-300A	3.00	1.92	1.000	19.83	3.58
T- 80	.795	.495	.250	5.15	.242	T-400	4.00	2.25	.650	24.93	3.66
T- 94	.942	.560	.312	6.00	.385	T-400A	4.00	2.25	1.000	24.93	7.43
T-106	1.060	.570	.437	6.50	.690	T-500	5.20	3.08	.800	33.16	5.46

A_L Values (uh / 100 turns)

For complete part number, add Mix number to Core Size number.

Core Size \/ Mhz>	26 Mix Yel-Wh u = 75 Pwr Frq	3 Mix Gray u = 35 .05 -0.5	15 Mix Rd-Wh u = 25 0.1 - 2.	1 Mix Blue u = 20 0.5 - 5.	2 Mix Red u = 10 2 - 30	6 Mix Yellow u = 8 10 - 50	10 Mix Black u = 6 30-100	12 Mix Grn-Wh u = 4 50-200	0 Mix Tan u = 1 100-300
T- 12-	na	60	50	48	20	17	12	7.5	3.0
T- 16-	145	61	55	44	22	19	13	8 0	3.0
T- 20-	180	76	65	52	27	22	16	10.0	3.5
T- 25-	235	100	85	70	34	27	19	12.0	4.5
T- 30-	325	140	93	85	43	36	25	16.0	6.0
T- 37-	275	120	90	80	40	30	25	15.0	4.9
T- 44-	360	180	160	105	52	42	33	18.5	6.5
T- 50-	320	175	135	100	49	40	31	18.0	6.4
T- 68-	420	195	180	115	57	47	32	21.0	7.5
T- 80-	450	180	170	115	55	45	32	22.0	8.5
T- 94-	590	248	200	160	84	70	58	32.0	10.6
T-106-	900	450	345	325	135	116	na	na	19.0
T-130-	785	350	250	200	110	96	na	na	15.0
T-157-	970	420	360	320	140	115	na	na	na
T-184-	1640	720	na	500	240	195	na	na	na
T-200-	895	425	na	250	120	100	na	na	na
T-200A-	1550	760	na	na	218	180	na	na	na
T-225-	950	424	na	na	120	100	na	na	na
T-225A-	1600	na	na	na	215	na	na	na	na
T-300-	800	na	na	na	114	na	na	na	na
T-300A-	1600	na	na	na	228	na	na	na	na
T-400-	1300	na	na	na	185	na	na	na	na
T-400A-	2600	na	na	na	360	na	na	na	na
T-500-	1460	na	na	na	207	na	na	na	na

na - not available.

Copper Wire Table

Wire size AWG	Diameter in inches (enamel)	Circular mil area	Turns per linear inch	Turns per sq.cm	Contineous duty current (amps) single wire,open air	Contineous duty,(amps) conduit or in wire bundles
8	.1285	16510	7.6		73	46
10	.1019	10380	10.7	13.8	55	33
12	.0808	6530	12.0	21.7	41	23
14	.0640	4107	15.0	34.1	32	17
16	.0508	2583	18.9	61.2	22	13
18	.0403	1624	23.6	79.1	16	10
20	.0319	1022	29.4	124.0	11	7.5
22	.0253	642	37.0	186.0	--	5.0
24	.0201	404	46.3	294.0	--	---
26	.0159	254	58.0	465.0	--	---
28	.0126	160	72.7	728.0	--	---
30	.0100	101	90.5	1085.0	--	---
32	.0079	63	113.0	1628.0	--	---
34	.0063	40	141.0	2480.0	--	---
36	.0050	25	175.0	3876.0	--	---
38	.0039	16	224.0	5736.0	--	---
40	.0031	10	382.0	10077.0	--	---

Iron Powder Core Size vs.Turns & Wire Size

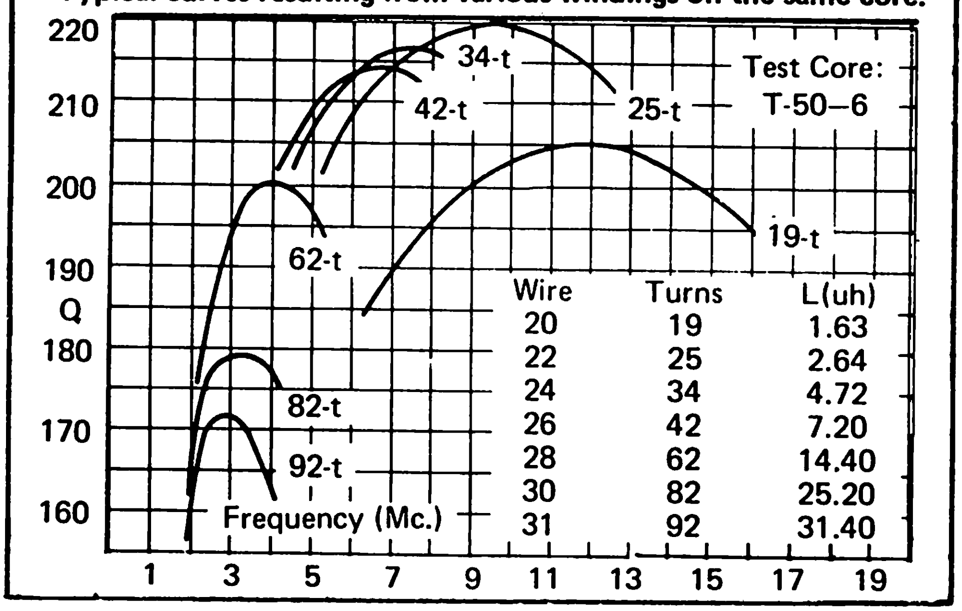
Approximate number of turns for a full single layer winding

Wire Sz. Core\/No.	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
T-12	0	0	0	1	1	1	2	4	5	8	11	15	21	29	37	47
T-16	0	0	1	1	1	3	3	5	8	11	16	21	29	38	49	63
T-20	0	1	1	1	3	4	5	6	9	14	18	25	33	43	56	72
T-25	1	1	1	3	4	5	7	11	15	21	28	37	48	62	79	101
T-30	1	1	3	4	5	7	11	15	21	28	37	48	62	78	101	129
T-37	1	3	5	7	9	12	17	23	31	41	53	67	87	110	140	177
T-44	3	5	6	7	10	15	20	27	35	46	60	76	97	124	157	199
T-50	5	6	8	11	16	21	28	37	49	63	81	103	131	166	210	265
T-68	7	9	12	15	21	28	36	47	61	79	101	127	162	205	257	325
T-80	8	12	17	23	30	39	51	66	84	108	137	172	219	276	347	438
T-94	10	14	20	27	35	45	58	75	96	123	156	195	248	313	393	496
T-106	10	14	20	27	35	45	58	75	96	123	156	195	248	313	393	496
T-130	17	23	30	40	51	66	83	107	137	173	220	275	348	439	550	693
T-157	22	29	38	50	64	82	104	132	168	213	270	336	426	536	672	846
T-184	22	29	38	50	64	82	104	132	168	213	270	336	426	536	672	846
T-200	31	41	53	68	86	109	139	176	223	282	357	445	562	707	886	1115
T-225	36	46	60	77	98	123	156	198	250	317	400	499	631	793	993	1250
T-300	52	66	85	108	137	172	217	274	347	438	553	688	870	1093	1368	1721
T-400	61	79	100	127	161	202	255	322	407	513	648	806	1018	1278	1543	2013
T-520	86	110	149	160	223	279	349	443	559	706	889	1105	1396	1753	2192	2758

IRON-POWDER TOROIDAL CORES

TYPICAL 'Q' CURVES
various windings, same core

Typical curves resulting from various windings on the same core.

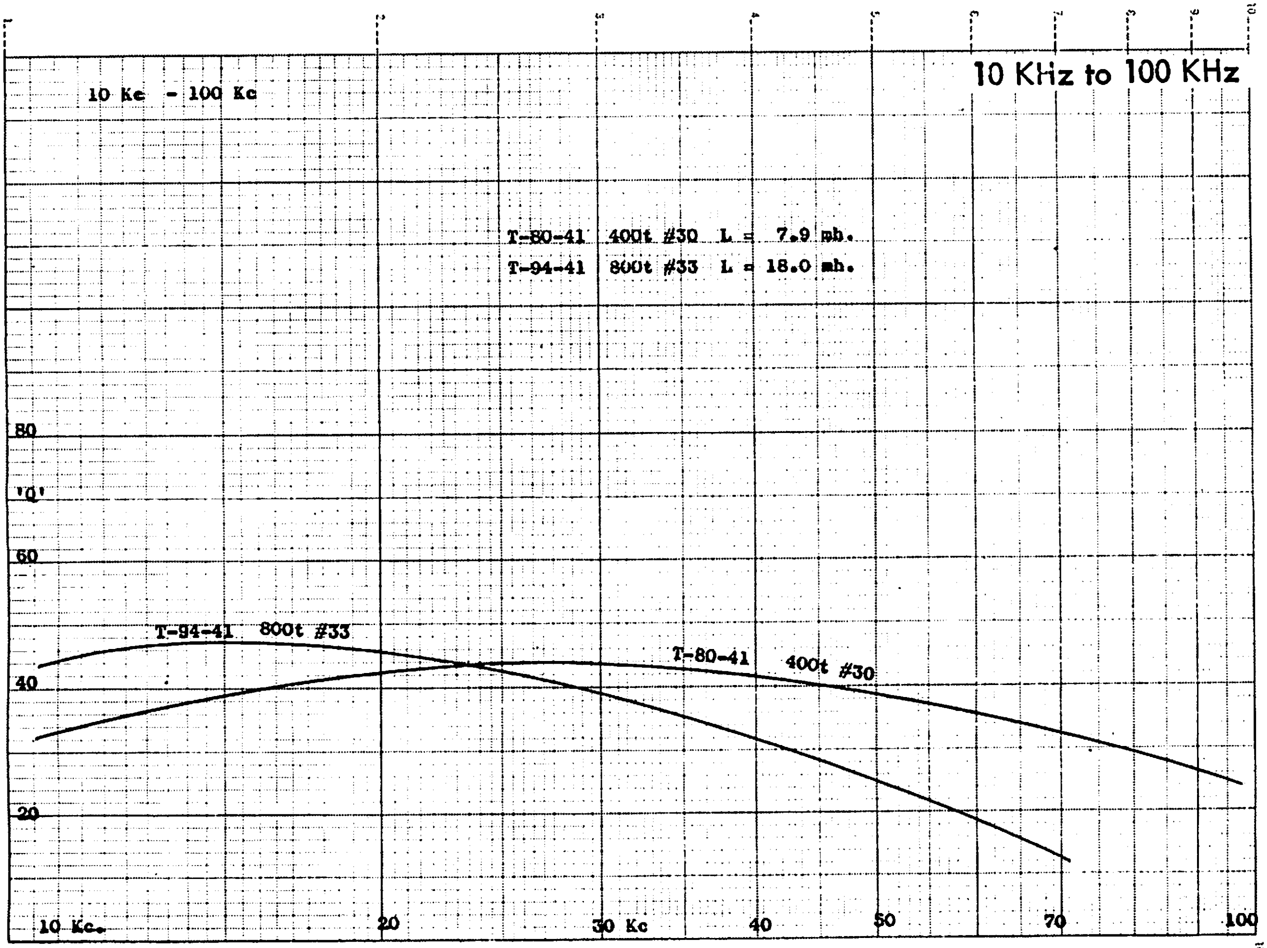


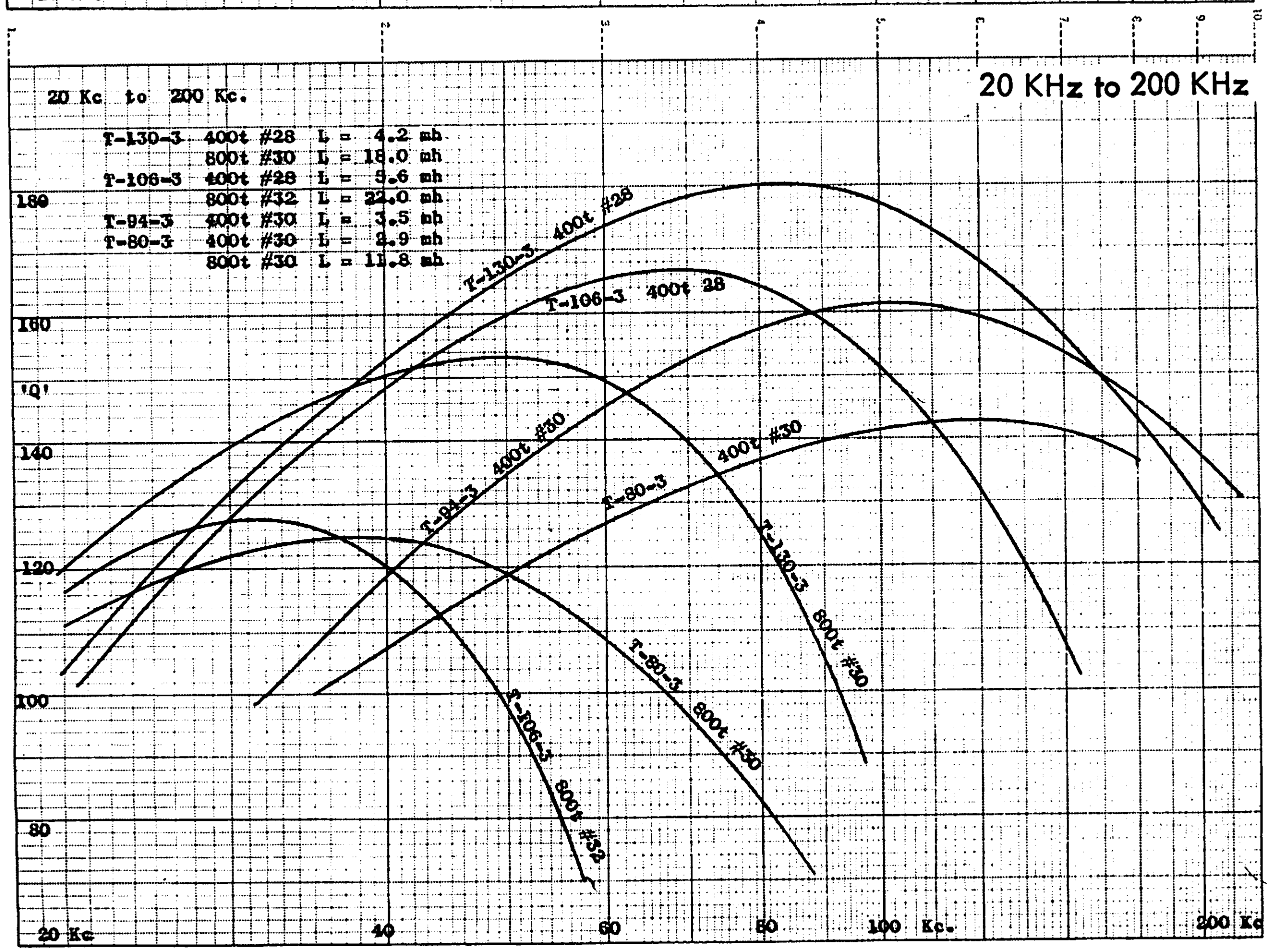
Wire	Turns	L(uh)
20	19	1.63
22	25	2.64
24	34	4.72
26	42	7.20
28	62	14.40
30	82	25.20
31	92	31.40

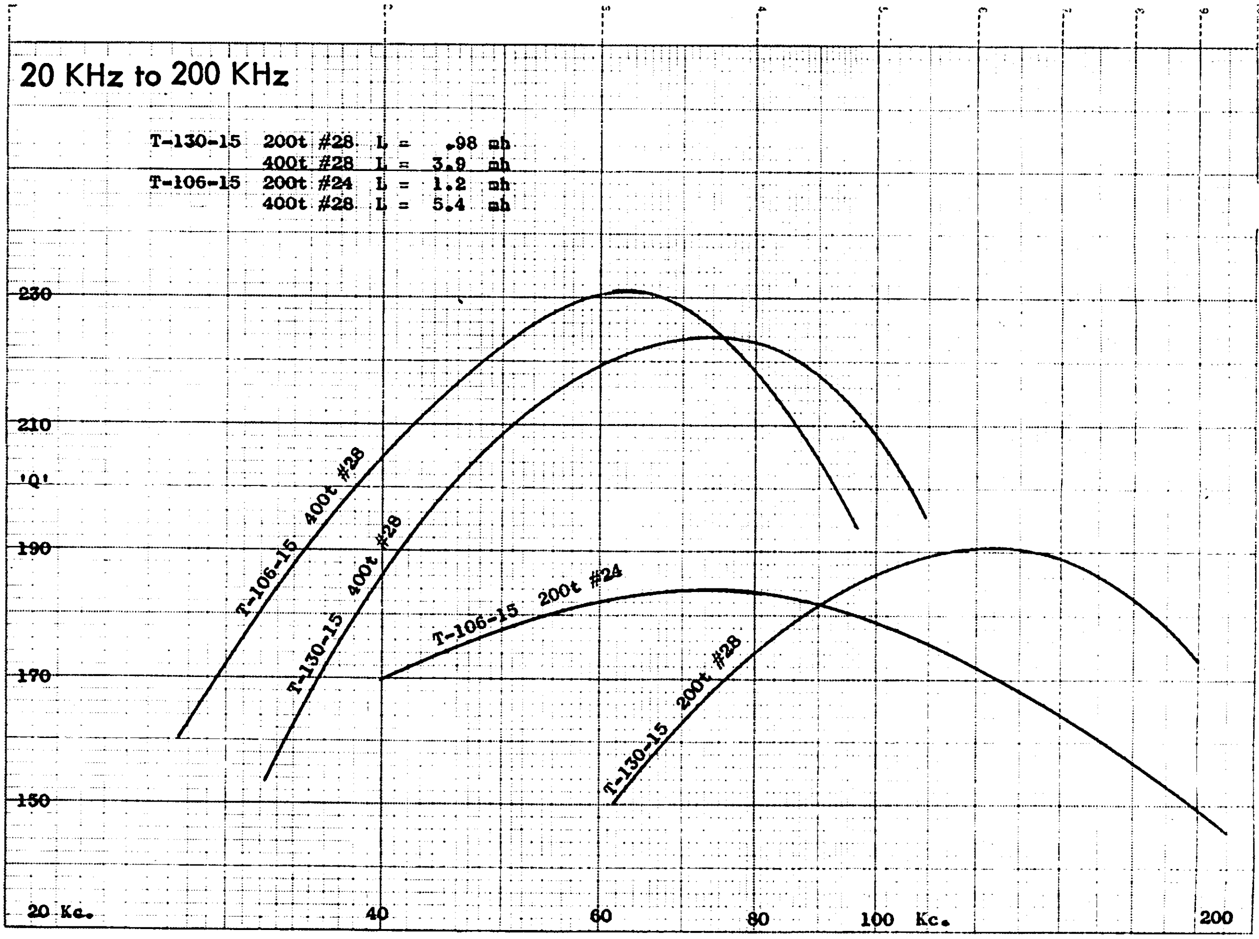
The above chart shows typical Q curves resulting from a number of various windings on the same toroidal core.

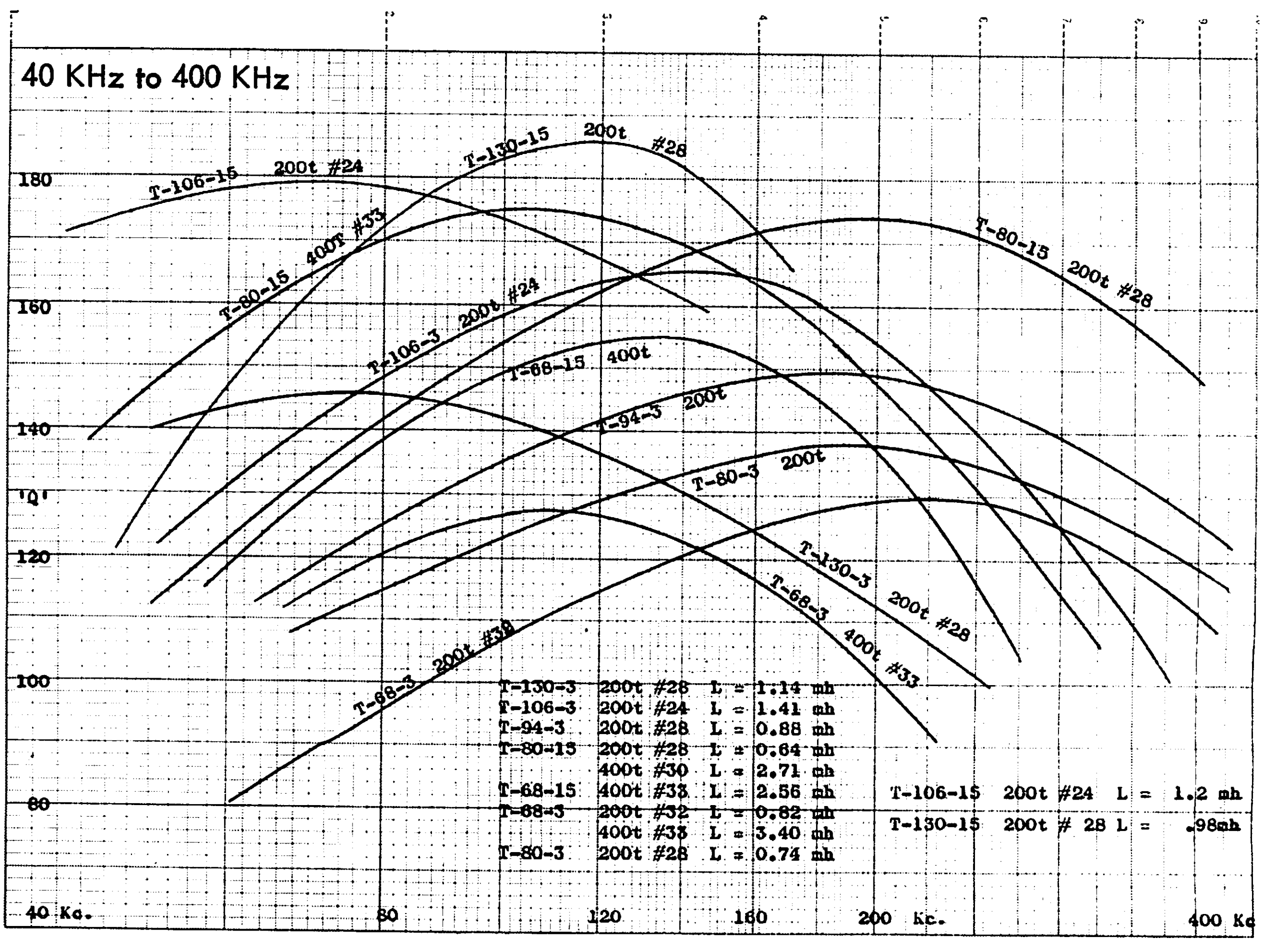
The next several pages contain a number of Q curves which were measured and plotted from actual windings.

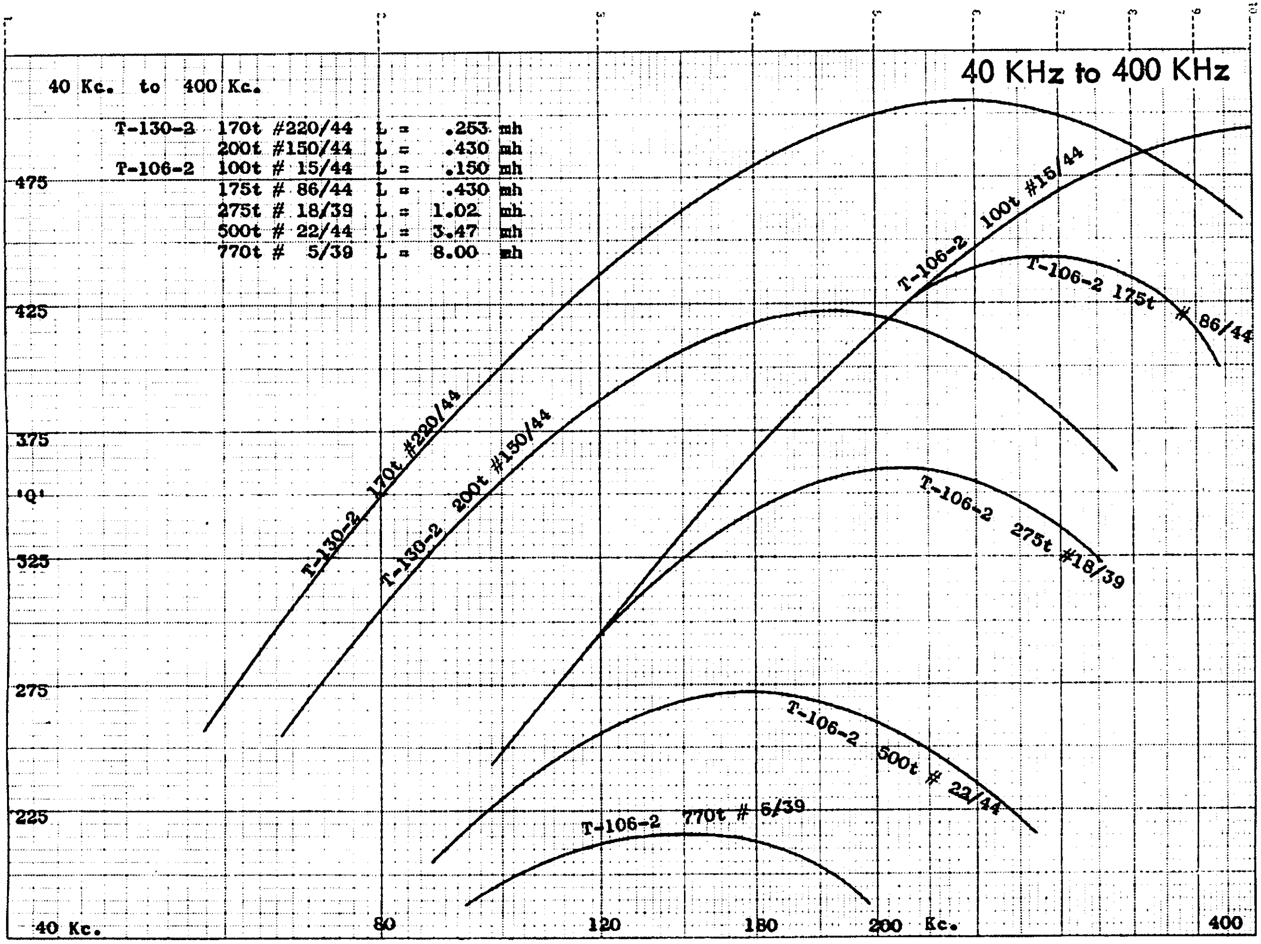
Inductance charts are given later on in this booklet which will help you choose a core for a specific inductance. Since the charts are in increments of ten turns, a more precise turns-count can be calculated with the turns vs. inductance equation once the core has been selected.

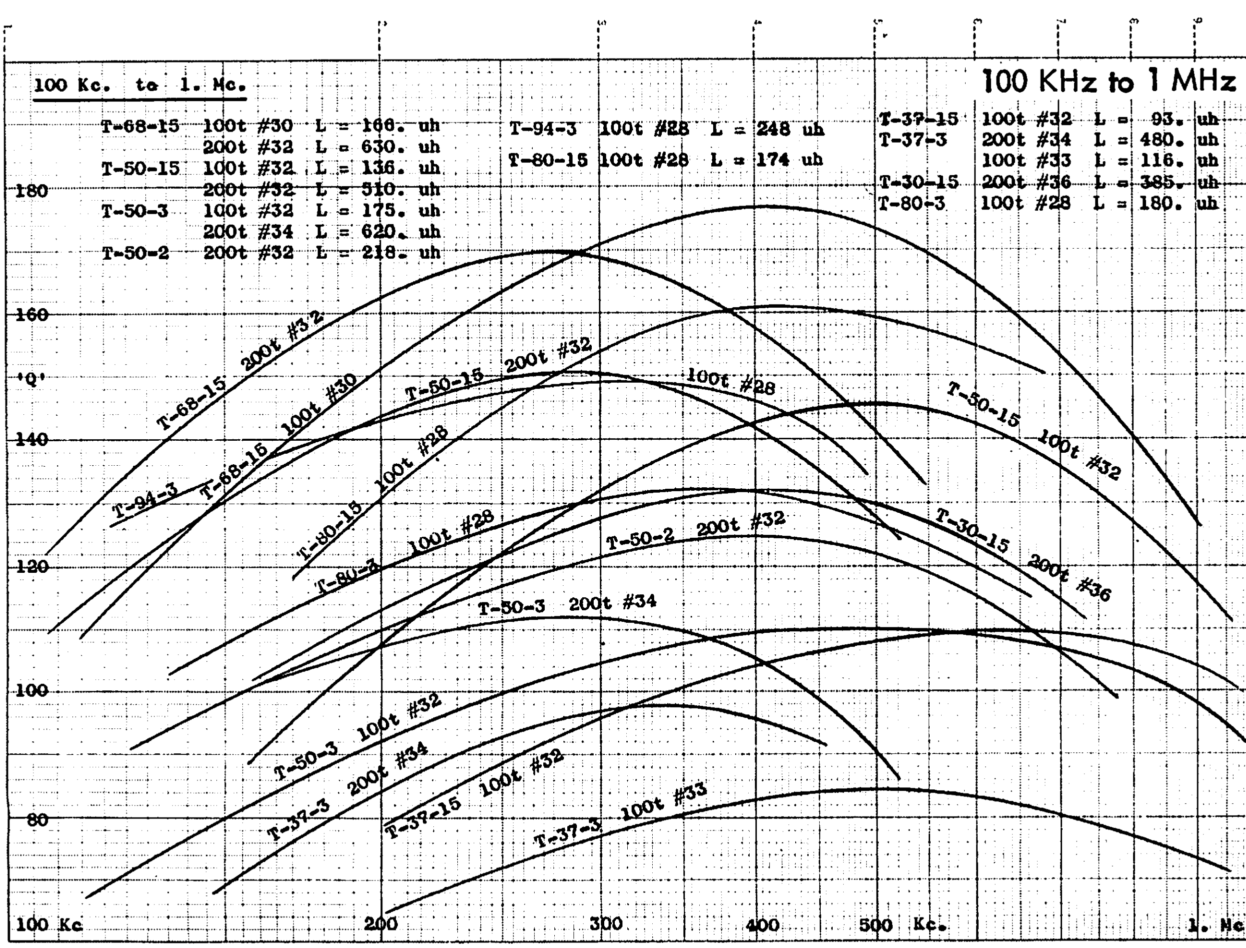

10 KHz to 100 KHz
10 Kc - 100 Kc
T-80-41 400t #30 L = 7.9 mh.
T-94-41 800t #33 L = 18.0 mh.
80
'Q'
60
40
20
T-94-41 800t #33
T-80-41 400t #30
10 Kc.
20
30 Kc
40
50
70
100

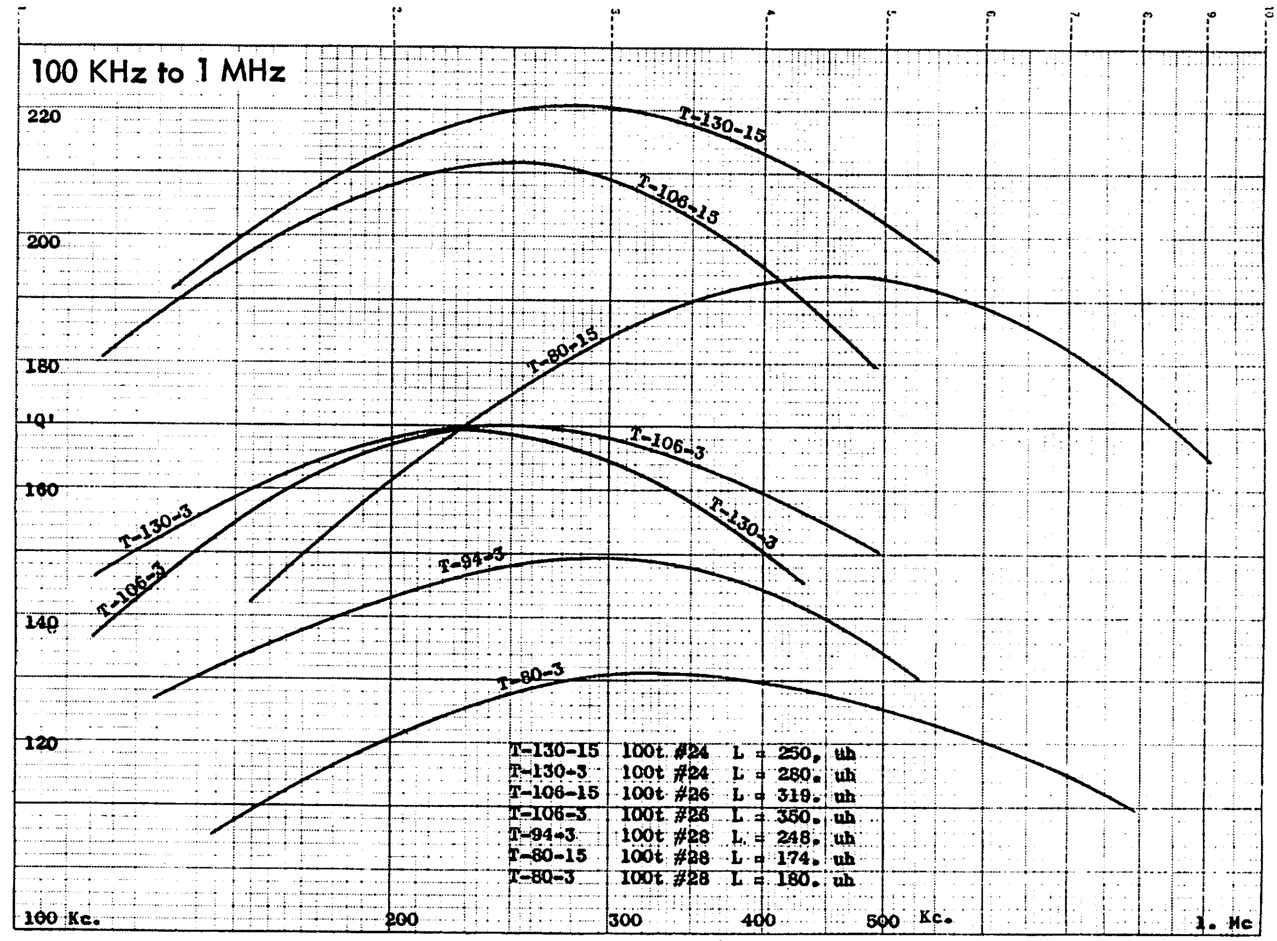

20 KHz to 200 KHz
20 Kc to 200 Kc.
T-130-3 400t #28 L = 4.2 mh
800t #30 L = 18.0 mh
T-106-3 400t #28 L = 5.6 mh
800t #32 L = 22.0 mh
T-94-3 400t #30 L = 3.5 mh
T-80-3 400t #30 L = 2.9 mh
800t #30 L = 11.8 mh
180
160
'Q'
140
120
100
80
T-130-3 400t #28
T-106-3 400t 28
T-94-3 400t #30
T-80-3
400t #30
T-130-3 800t #30
T-80-3 800t #30
T-106-3 800t #32
20 Kc
40
60
80
100 Kc.
200 Kc

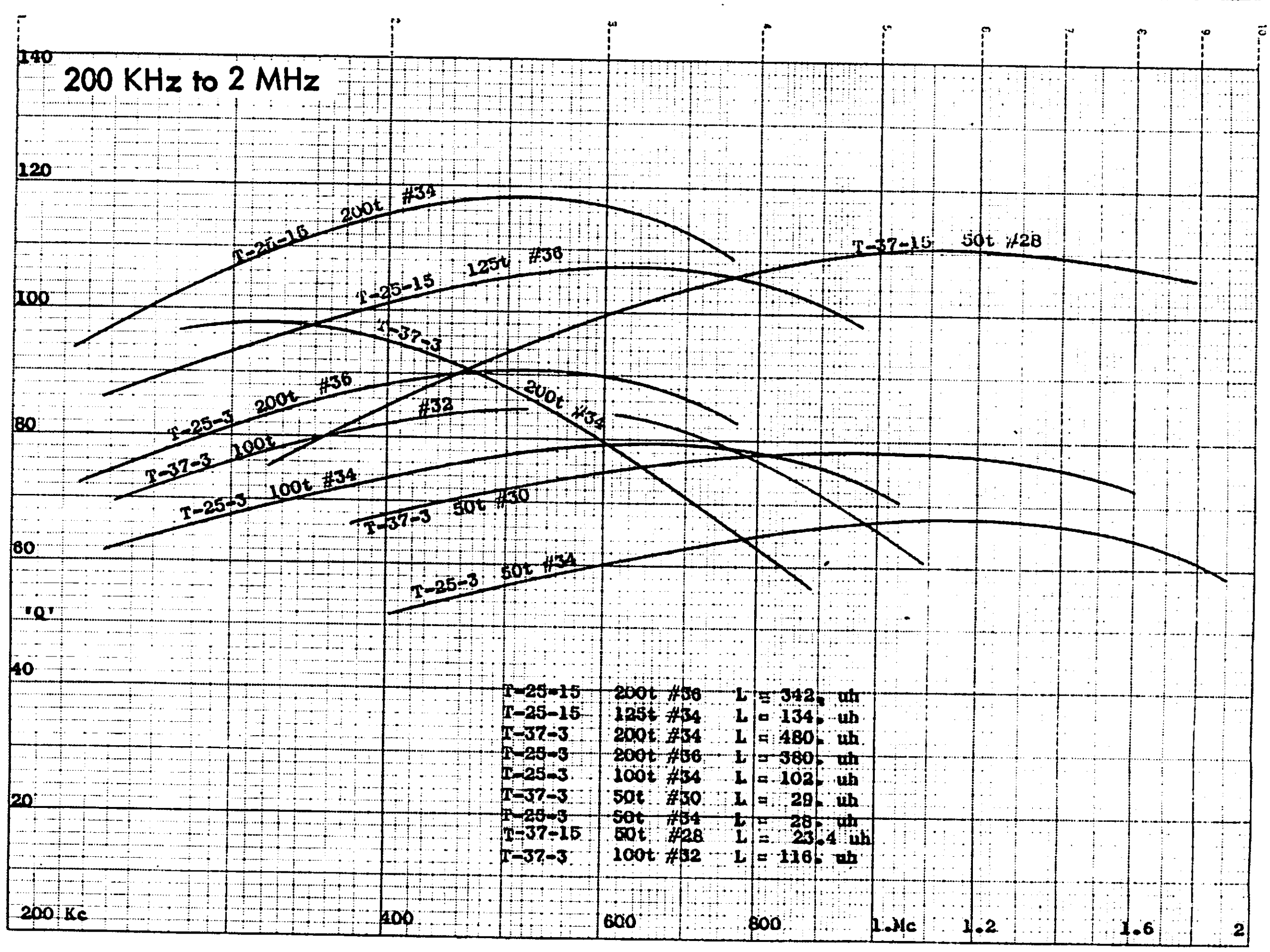

20 KHz to 200 KHz
T-130-15 200t #28 L = .98 mh
400t #28 L = 3.9 mh
T-106-15 200t #24 L = 1.2 mh
400t #28 L = 5.4 mh
230
210
'Q'
190
170
150
T-106-15 400t #28
T-130-15 400t #28
T-106-15 200t #24
T-130-15 200t #28
20 Kc.
40
60
80
100 Kc.
200


40 KHz to 400 KHz
T-130-15 200t #28
T-106-15 200t #24
T-80-15 400T #33
T-106-3 200t #24
T-68-15 400t
T-94-3 200t
T-80-3 200t
T-80-15 200t #28
T-130-3 200t #28
T-68-3 400t #33
T-68-3 200t #32
180
160
140
'Q'
120
100
80
T-130-3 200t #28 L = 1.14 mh
T-106-3 200t #24 L = 1.41 mh
T-94-3 200t #28 L = 0.88 mh
T-80-15 200t #28 L = 0.64 mh
400t #30 L = 2.71 mh
T-68-15 400t #33 L = 2.56 mh
T-68-3 200t #32 L = 0.82 mh
400t #33 L = 3.40 mh
T-80-3 200t #28 L = 0.74 mh
T-106-15 200t #24 L = 1.2 mh
T-130-15 200t # 28 L = .98mh
40 Kc.
80
120
160
200 Kc.
400 Kc

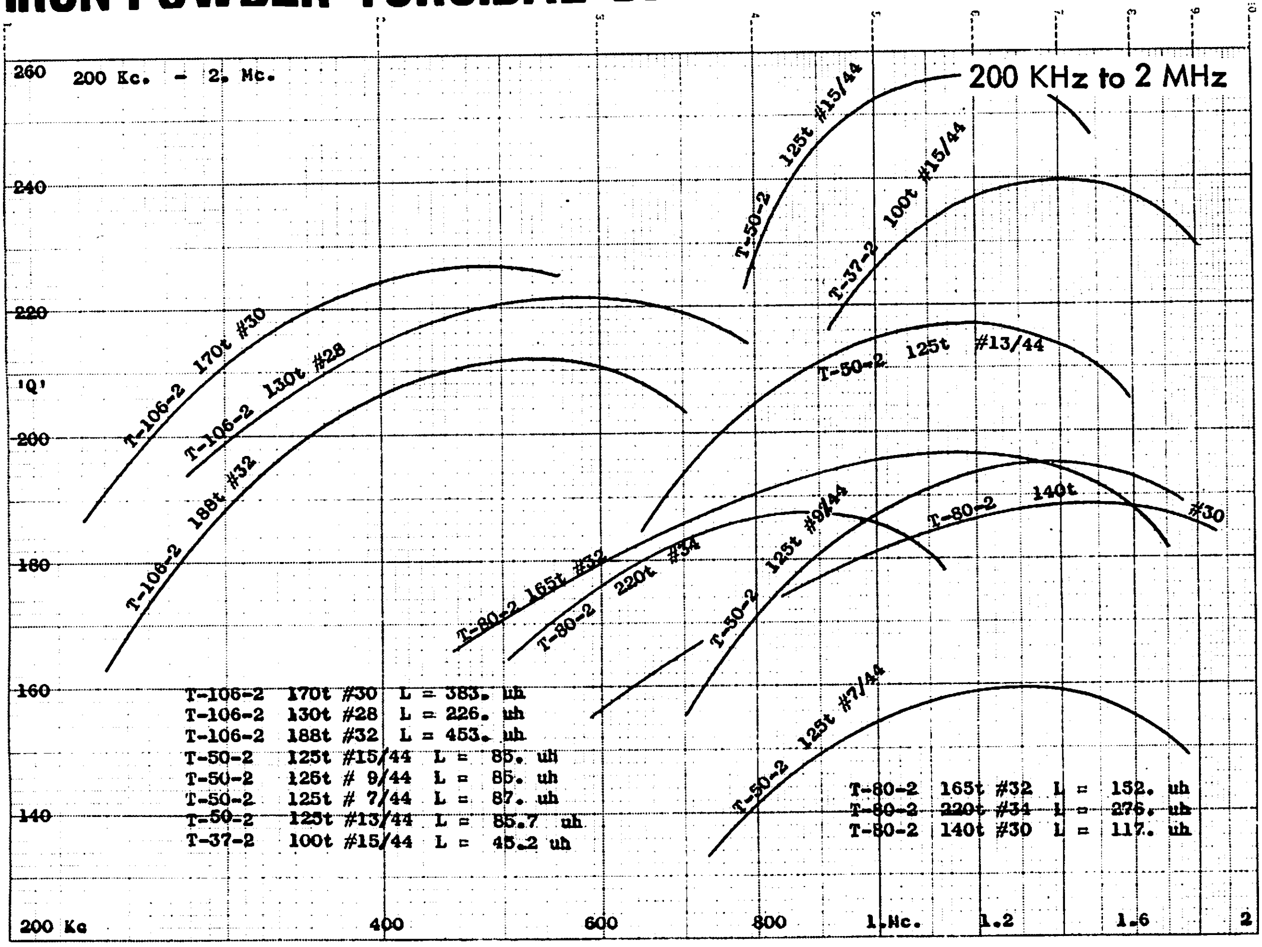

40 KHz to 400 KHz
40 Kc. to 400 Kc.
T-130-2 170t #220/44 L = .253 mh
200t #150/44 L = .430 mh
T-106-2 100t # 15/44 L = .150 mh
175t # 86/44 L = .430 mh
275t # 18/39 L = 1.02 mh
500t # 22/44 L = 3.47 mh
770t # 5/39 L = 8.00 mh
475
425
375
'Q'
325
275
225
T-130-2 170t #220/44
T-130-2 200t #150/44
T-106-2 100t #15/44
T-106-2 175t # 86/44
T-106-2 275t #18/39
T-106-2 500t # 22/44
T-106-2 770t # 5/39
40 Kc.
80
120
160
200 Kc.
400

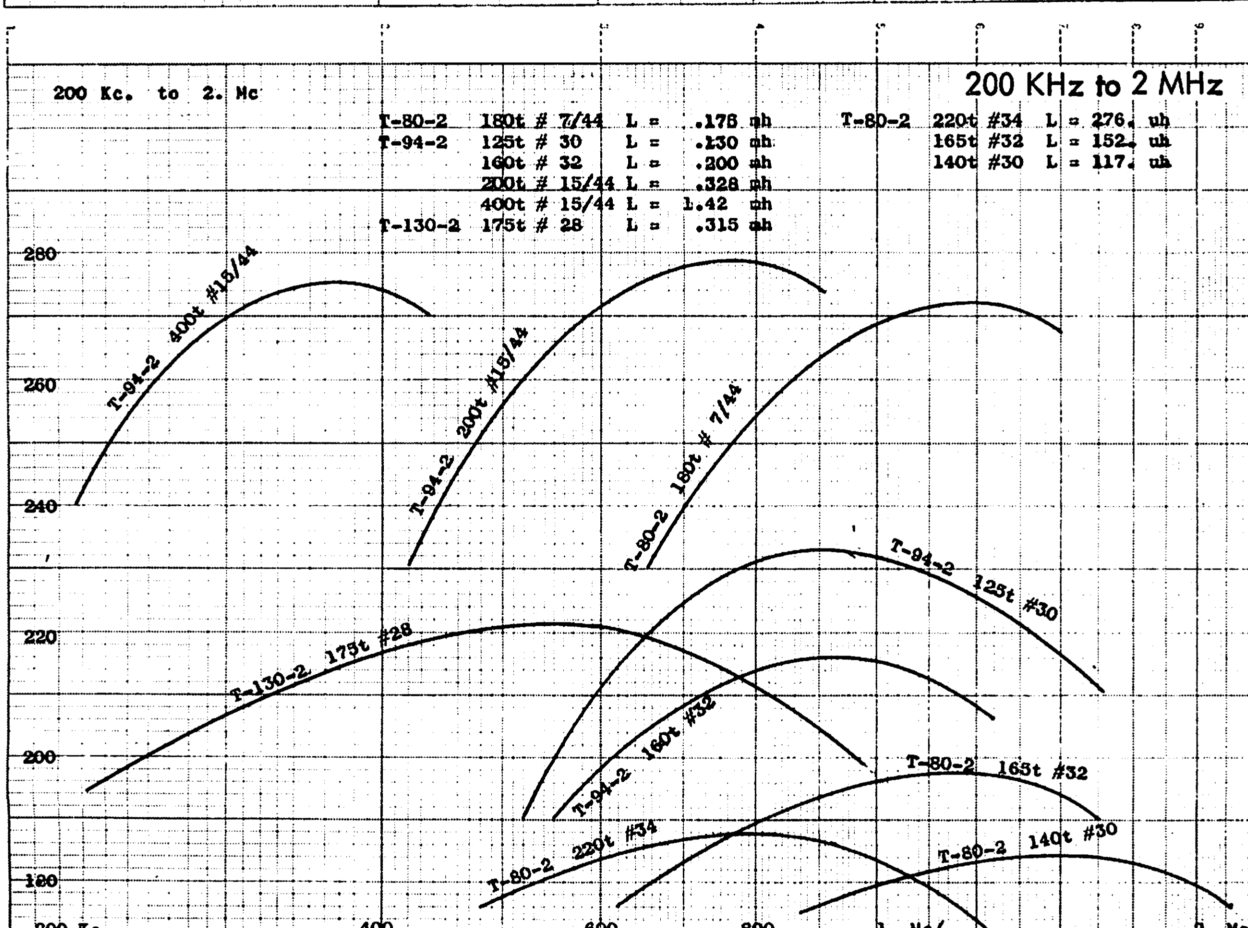

100 KHz to 1 MHz
100 Kc. to 1. Mc.
T-68-15 100t #30 L = 166. uh
200t #32 L = 630. uh
T-50-15 100t #32 L = 136. uh
200t #32 L = 510. uh
T-50-3 100t #32 L = 175. uh
200t #34 L = 620. uh
T-50-2 200t #32 L = 218. uh
T-94-3 100t #28 L = 248 uh
T-80-15 100t #28 L = 174 uh
T-37-15 100t #32 L = 93. uh
T-37-3 200t #34 L = 480. uh
100t #33 L = 116. uh
T-30-15 200t #36 L = 385. uh
T-80-3 100t #28 L = 180. uh
180
160
'Q'
140
120
100
80
T-68-15 200t #32
T-68-15 100t #30
T-50-15 200t #32
100t #28
T-50-15 100t #32
T-94-3
T-80-15 100t #28
T-80-3 100t #28
T-50-2 200t #32
T-30-15 200t #36
T-50-3 200t #34
T-50-3 100t #32
T-37-3 200t #34
T-37-15 100t #32
T-37-3 100t #33
100 Kc
200
300
400
500 Kc.
1. Mc.


100 KHz to 1 MHz
220
200
180
'Q'
160
140
120
T-130-15
T-106-15
T-80-15
T-106-3
T-130-3
T-130-3
T-106-3
T-94-3
T-80-3
T-130-15 100t #24 L = 250. uh
T-130-3 100t #24 L = 280. uh
T-106-15 100t #26 L = 319. uh
T-106-3 100t #26 L = 350. uh
T-94-3 100t #28 L = 248. uh
T-80-15 100t #28 L = 174. uh
T-80-3 100t #28 L = 180. uh
100 Kc.
200
300
400
500 Kc.
1. Mc

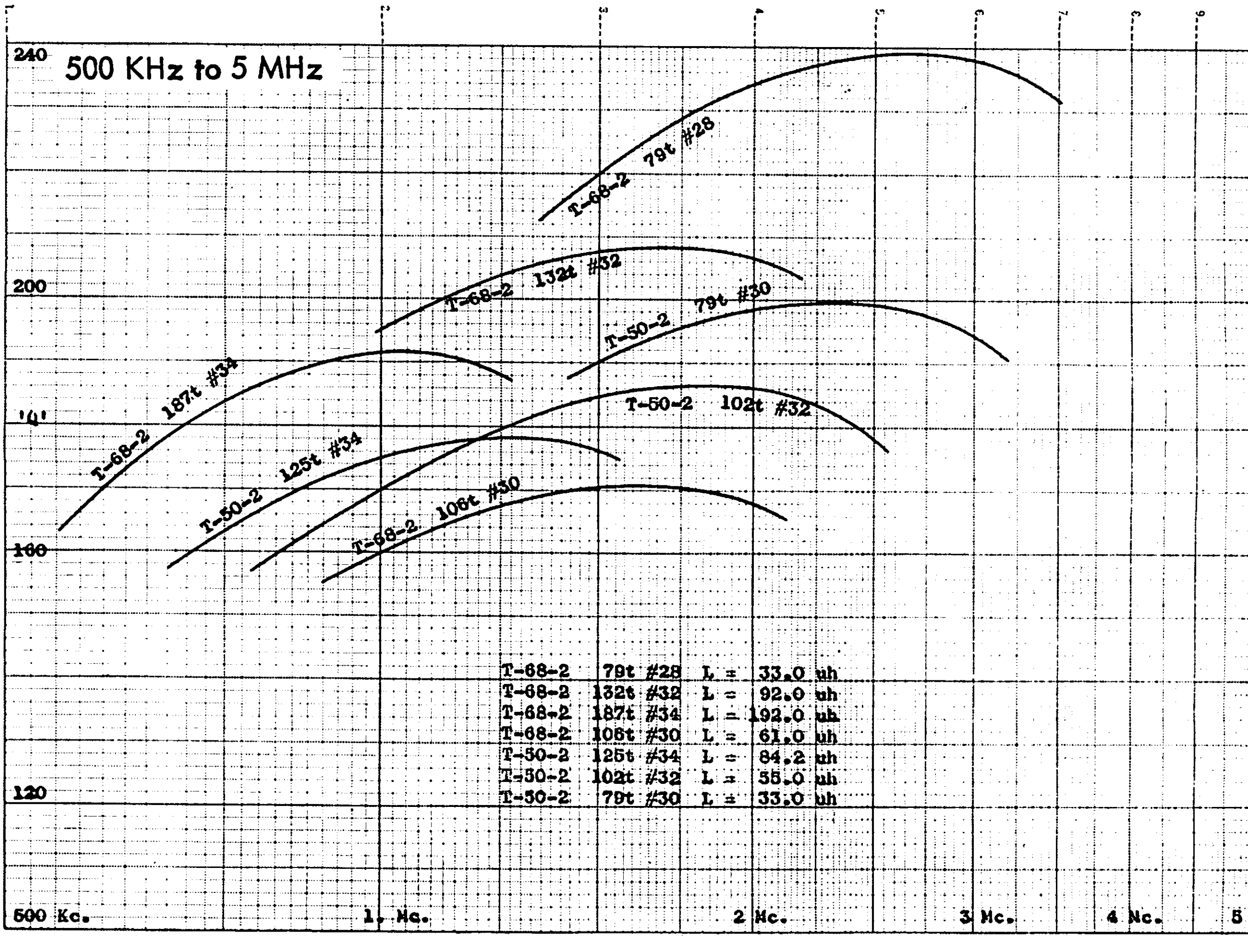

200 KHz to 2 MHz
140
120
100
80
60
'Q'
40
20
T-25-15 200t #34
T-25-15 125t #36
T-37-15 50t #28
T-37-3
200t #34
T-25-3 200t #36
#32
T-37-3 100t
T-25-3 100t #34
T-37-3 50t #30
T-25-3 50t #34
T-25-15 200t #36 L = 342. uh
T-25-15 125t #34 L = 134. uh
T-37-3 200t #34 L = 480. uh
T-25-3 200t #36 L = 360. uh
T-25-3 100t #34 L = 102. uh
T-37-3 50t #30 L = 29. uh
T-25-3 50t #34 L = 28. uh
T-37-15 50t #28 L = 23.4 uh
T-37-3 100t #32 L = 116. uh
200 Kc
400
600
800
1. Mc
1.2
1.6
2

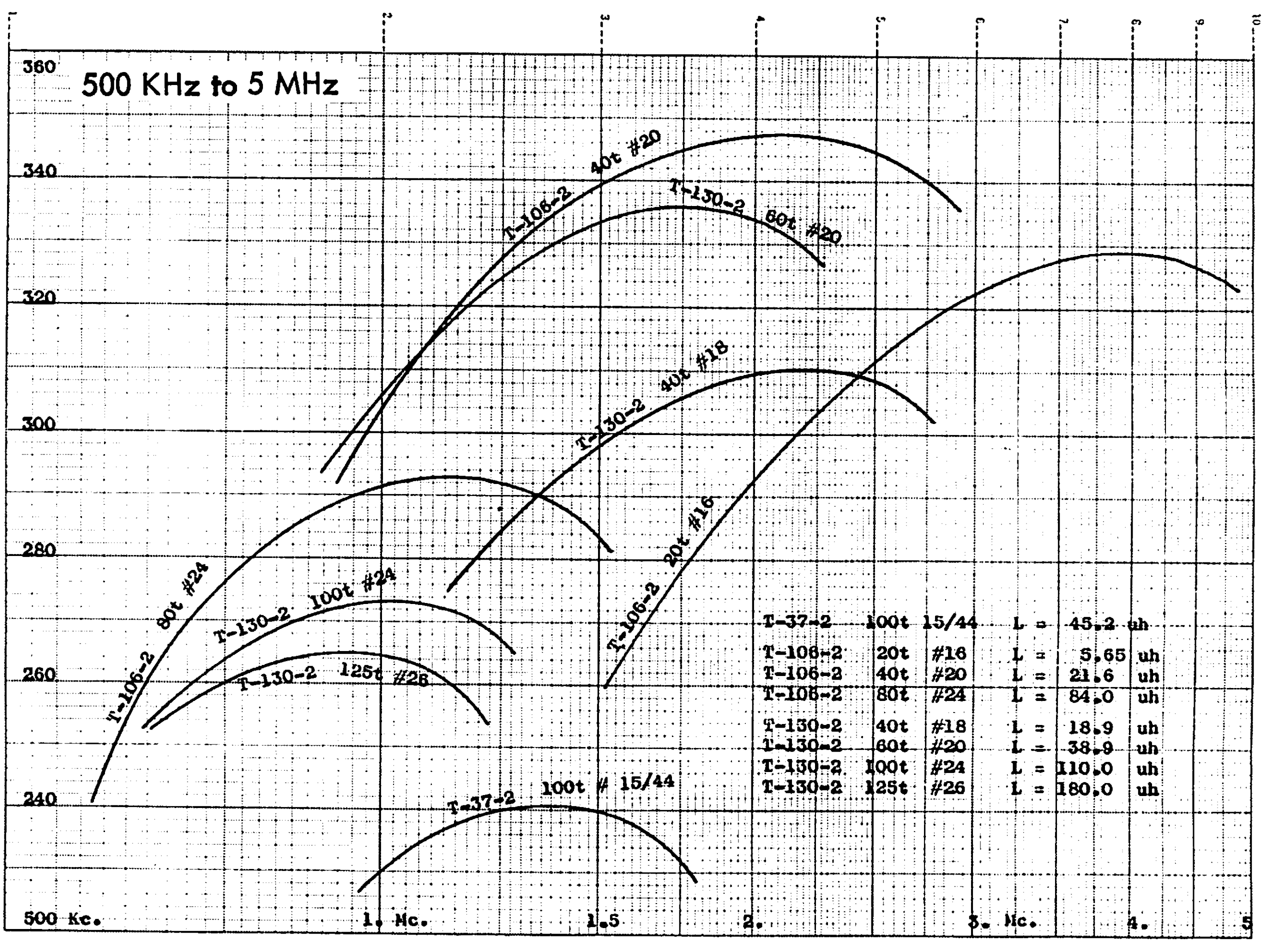
IRON-POWDER TOROIDAL CORES Q—CURVES

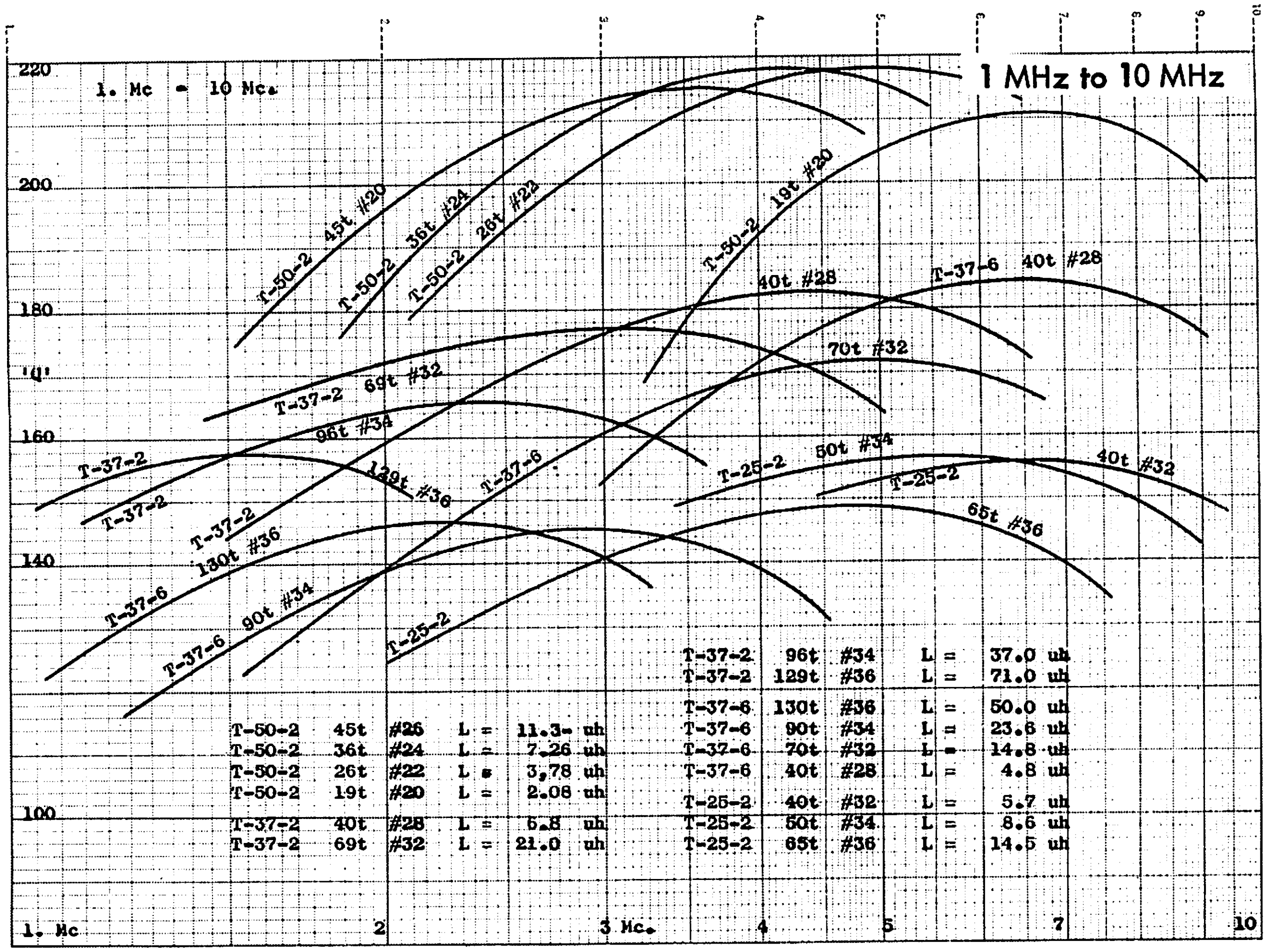


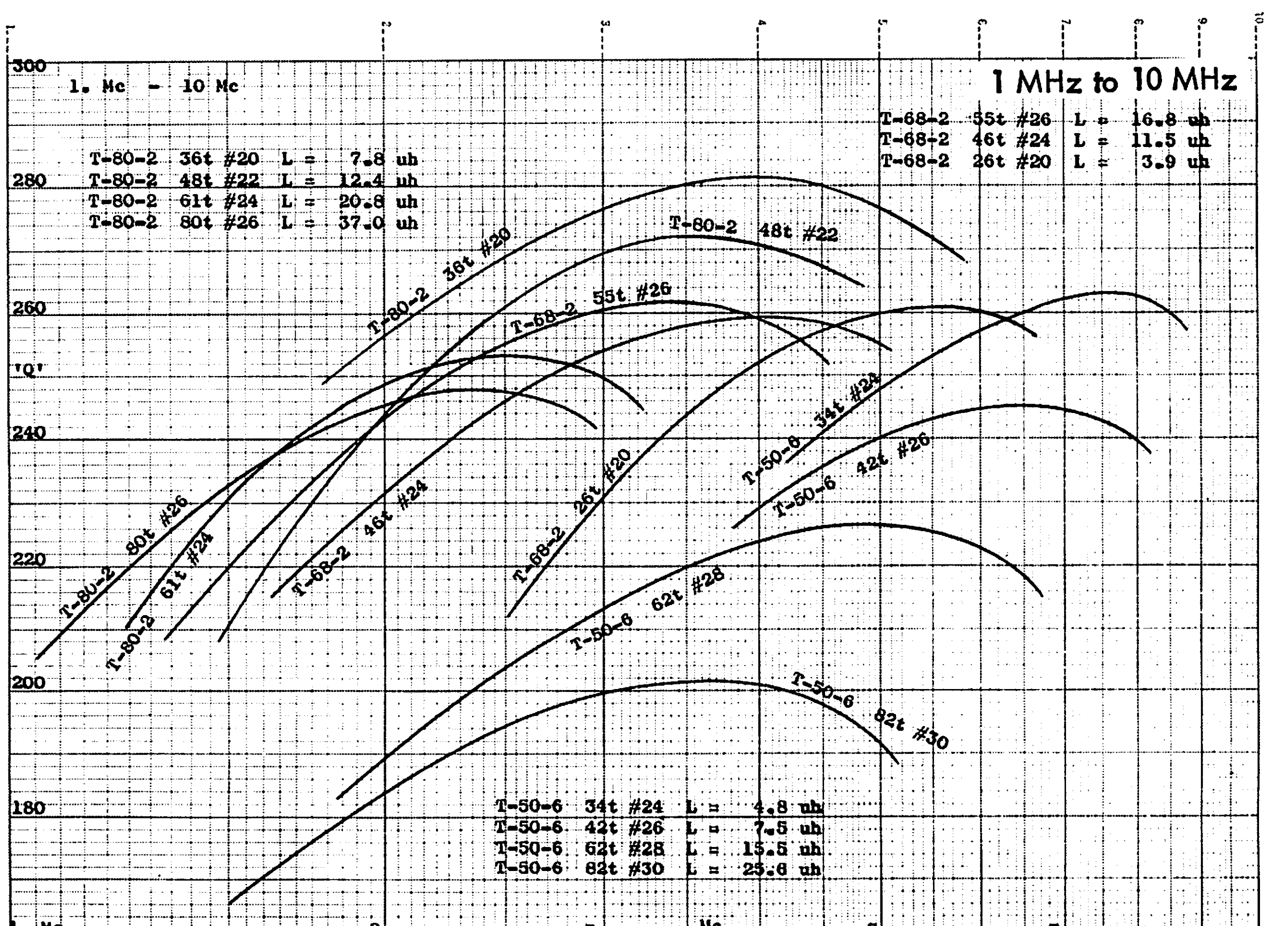


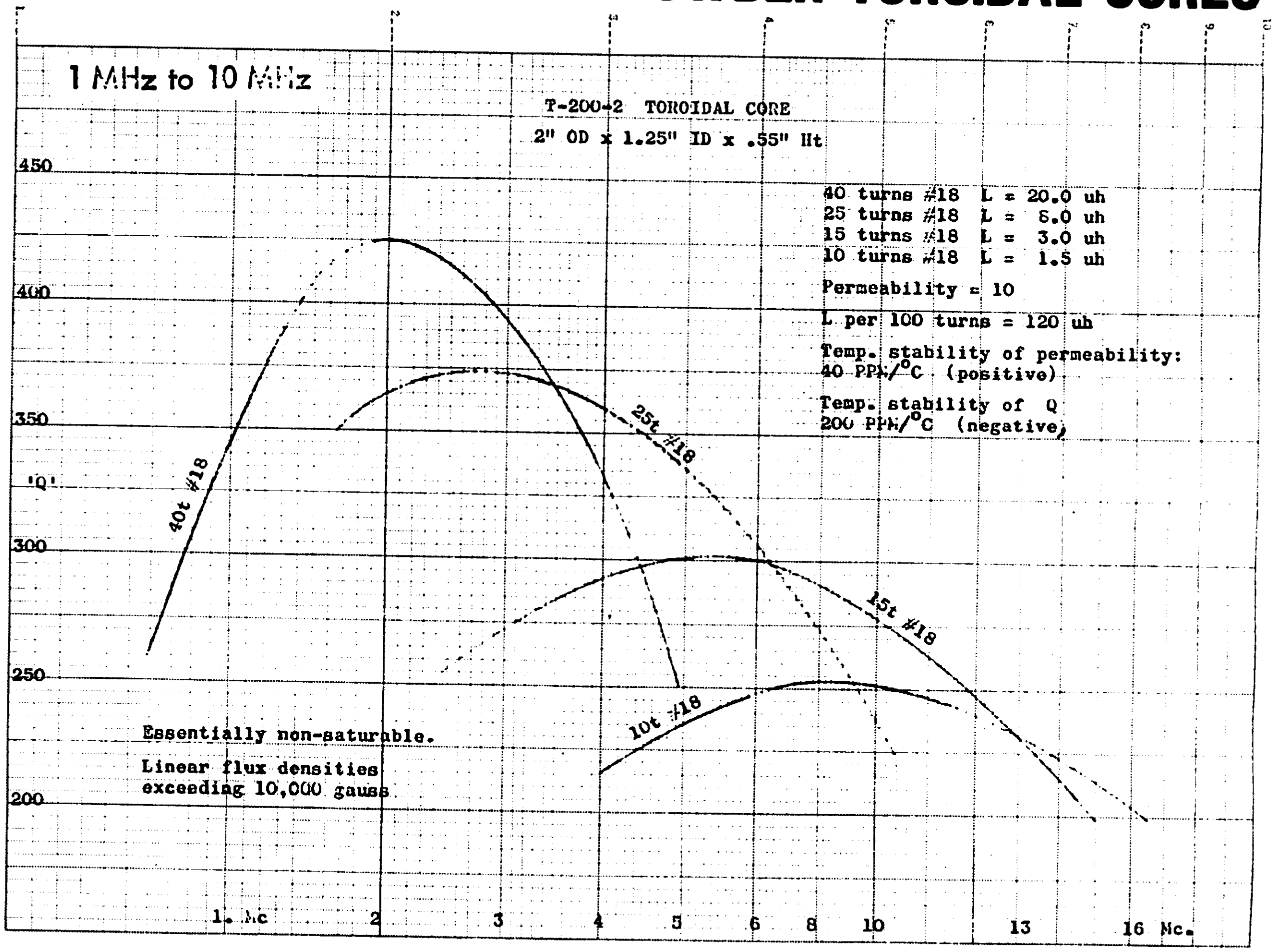
IRON-POWDER TOROIDAL CORES

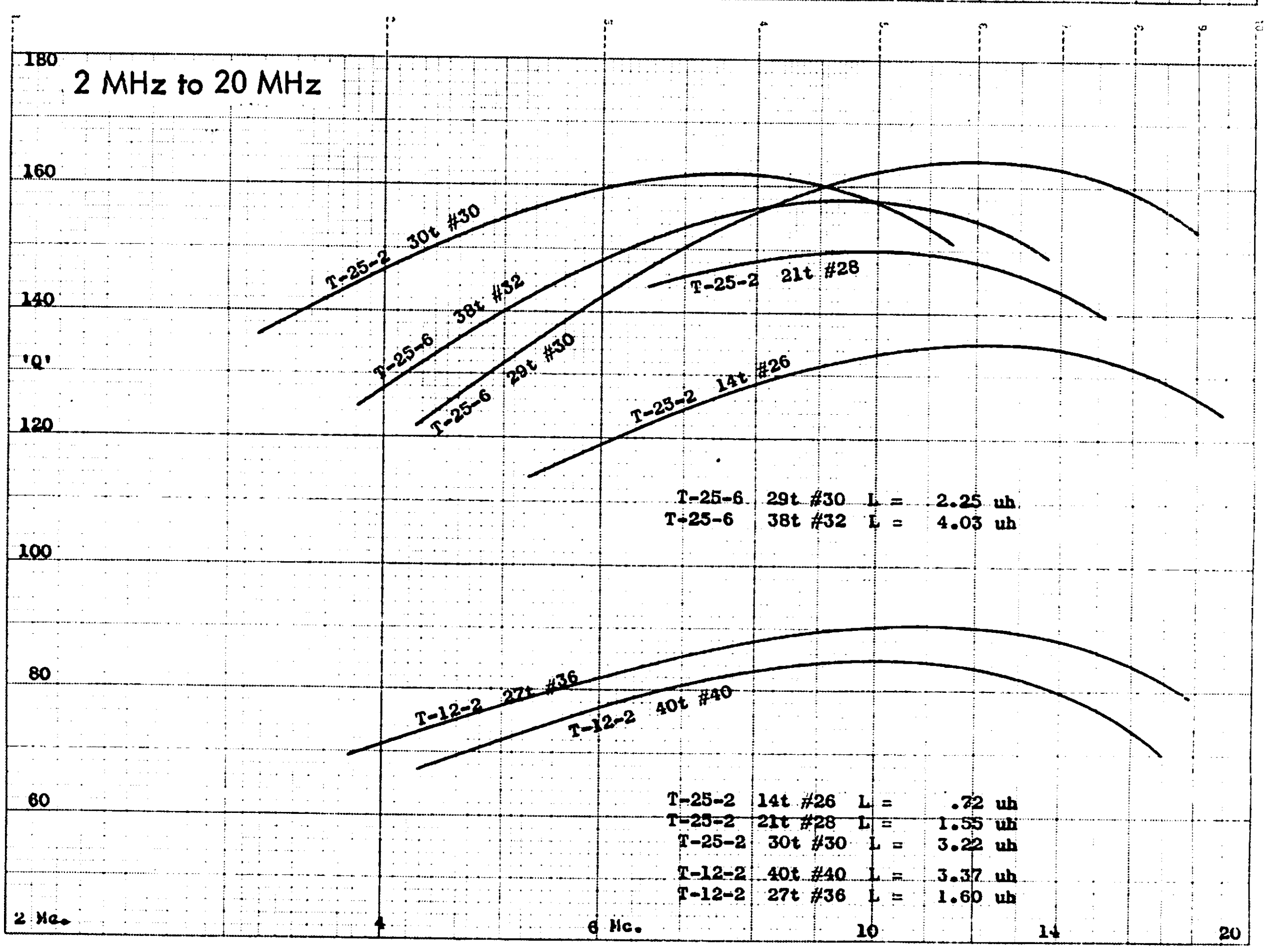





1 MHz to 10 MHz
1. Mc - 10 Mc.
'Q'
T-50-2 45t #20
T-50-2 36t #24
T-50-2 26t #22
T-50-2 19t #20
40t #28
T-37-6 40t #28
70t #32
T-37-2 69t #32
96t #34
T-37-2
129t #36
T-37-6
T-37-2
T-37-2
130t #36
T-25-2 50t #34
T-25-2
40t #32
65t #36
T-37-6
T-37-6 90t #34
T-25-2
T-37-2 96t #34 L = 37.0 uh
T-37-2 129t #36 L = 71.0 uh
T-37-6 130t #36 L = 50.0 uh
T-37-6 90t #34 L = 23.6 uh
T-37-6 70t #32 L = 14.8 uh
T-37-6 40t #28 L = 4.8 uh
T-25-2 40t #32 L = 5.7 uh
T-25-2 50t #34 L = 8.6 uh
T-25-2 65t #36 L = 14.5 uh
T-50-2 45t #26 L = 11.3 uh
T-50-2 36t #24 L = 7.26 uh
T-50-2 26t #22 L = 3.78 uh
T-50-2 19t #20 L = 2.08 uh
T-37-2 40t #28 L = 5.8 uh
T-37-2 69t #32 L = 21.0 uh
220
200
180
160
140
100
1. Mc
2
3 Mc.
4
5
7
10

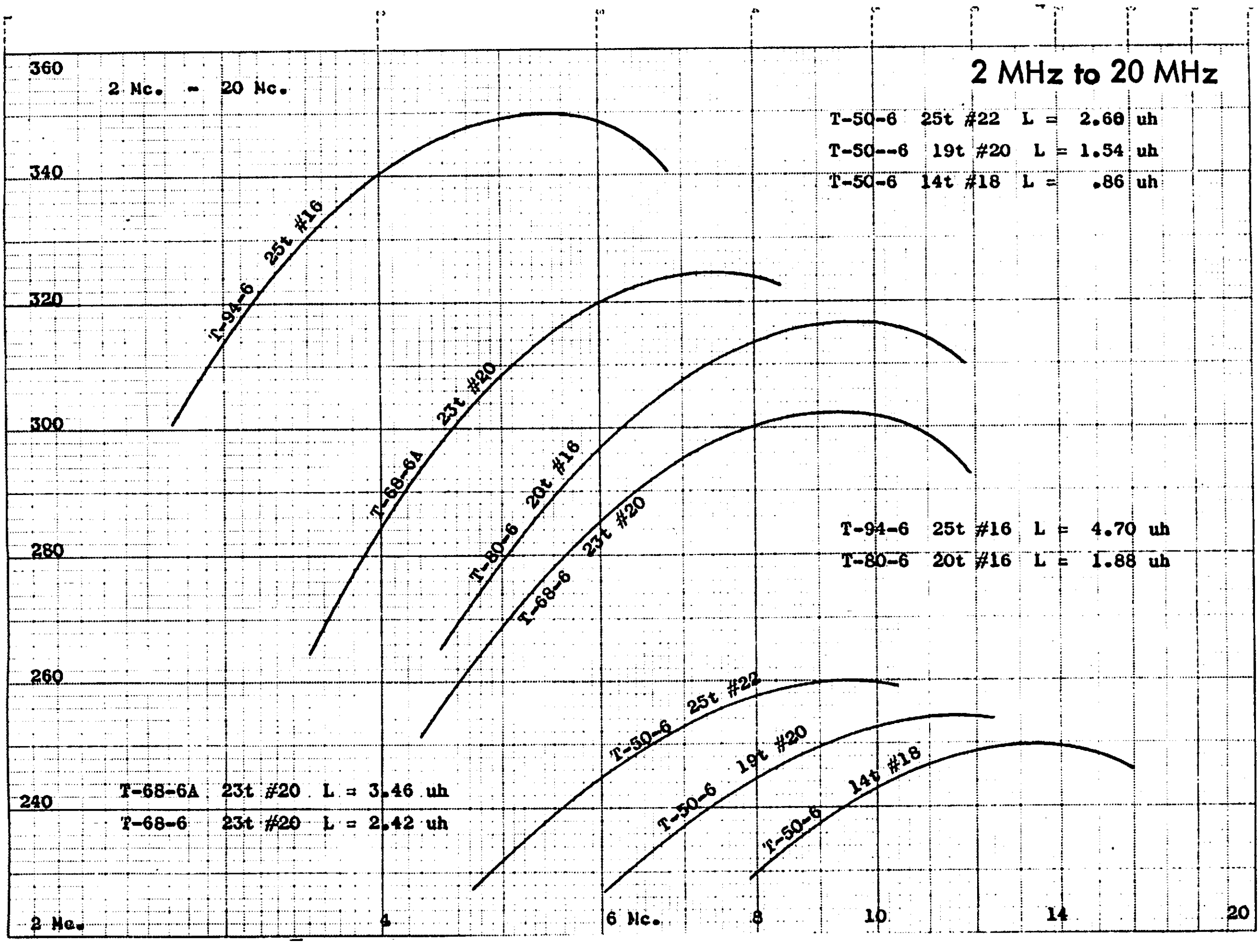

1 MHz to 10 MHz
1. Mc - 10 Mc
'Q'
T-68-2 55t #26 L = 16.8 uh
T-68-2 46t #24 L = 11.5 uh
T-68-2 26t #20 L = 3.9 uh
T-80-2 36t #20 L = 7.8 uh
T-80-2 48t #22 L = 12.4 uh
T-80-2 61t #24 L = 20.8 uh
T-80-2 80t #26 L = 37.0 uh
T-80-2 48t #22
T-80-2 36t #20
T-68-2 55t #26
T-50-6 34t #24
T-50-6 42t #26
T-80-2 80t #26
T-80-2 61t #24
T-68-2 46t #24
T-68-2 26t #20
T-50-6 62t #28
T-50-6 82t #30
T-50-6 34t #24 L = 4.8 uh
T-50-6 42t #26 L = 7.5 uh
T-50-6 62t #28 L = 15.5 uh
T-50-6 82t #30 L = 25.6 uh
300
280
260
240
220
200
180
1. Mc
2
3
Mc.
5
7
10

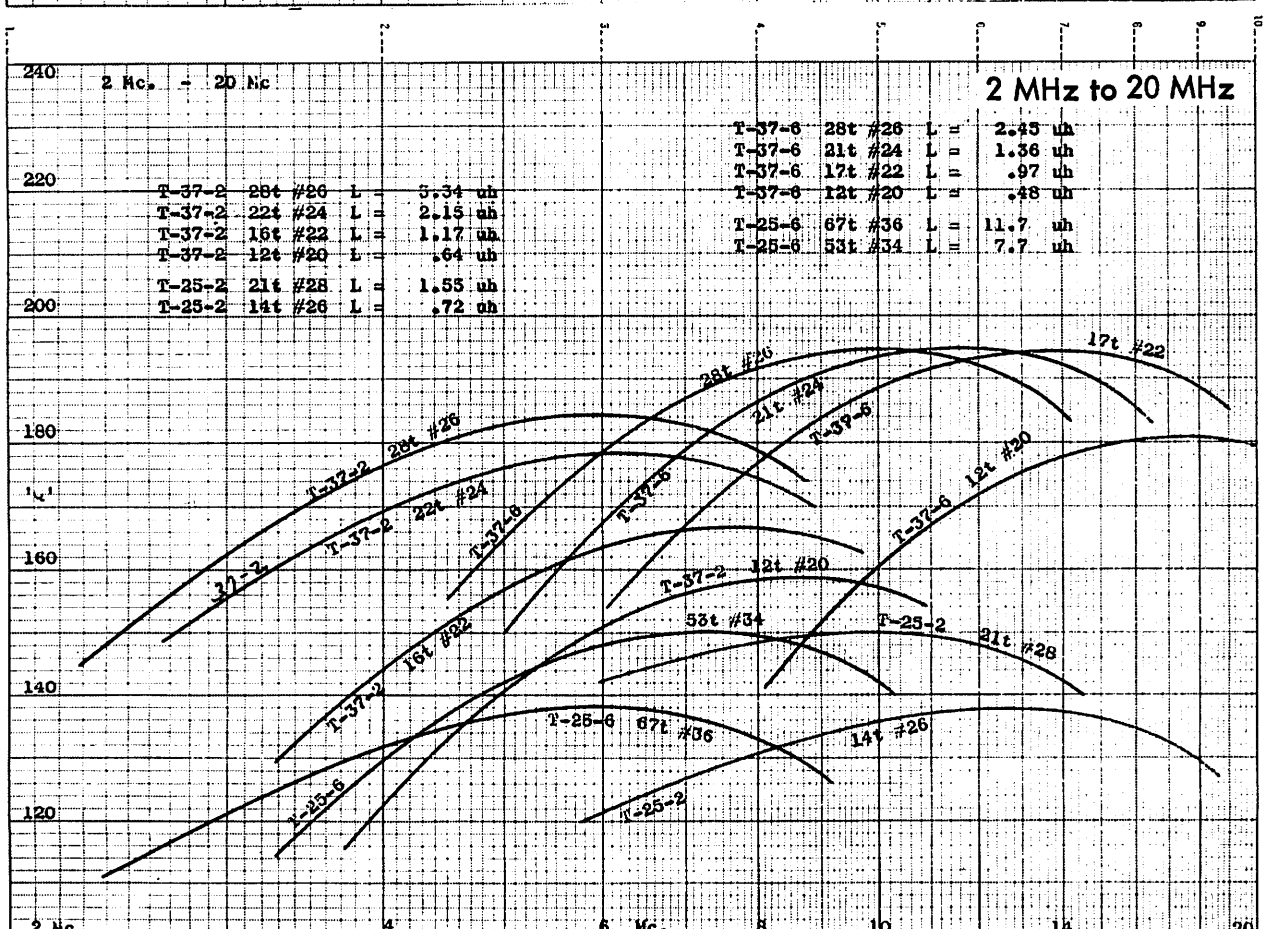

1 MHz to 10 MHz
T-200-2 TOROIDAL CORE
2" OD x 1.25" ID x .55" Ht
40 turns #18 L = 20.0 uh
25 turns #18 L = 8.0 uh
15 turns #18 L = 3.0 uh
10 turns #18 L = 1.5 uh
Permeability = 10
L per 100 turns = 120 uh
Temp. stability of permeability: 40 PPM/°C (positive)
Temp. stability of Q 200 PPM/°C (negative)
Essentially non-saturable.
Linear flux densities exceeding 10,000 gauss
40t #18
25t #18
15t #18
10t #18
'Q'
450
400
350
300
250
200
1. Mc
2
3
4
5
6
8
10
13
16 Mc.


2 MHz to 20 MHz
T-25-2 30t #30
T-25-6 38t #32
T-25-6 29t #30
T-25-2 21t #28
T-25-2 14t #26
T-12-2 27t #36
T-12-2 40t #40
T-25-6 29t #30 L = 2.25 uh
T-25-6 38t #32 L = 4.03 uh
T-25-2 14t #26 L = .72 uh
T-25-2 21t #28 L = 1.55 uh
T-25-2 30t #30 L = 3.22 uh
T-12-2 40t #40 L = 3.37 uh
T-12-2 27t #36 L = 1.60 uh
'Q'
180
160
140
120
100
80
60
2 Mc.
4
6 Mc.
10
14
20

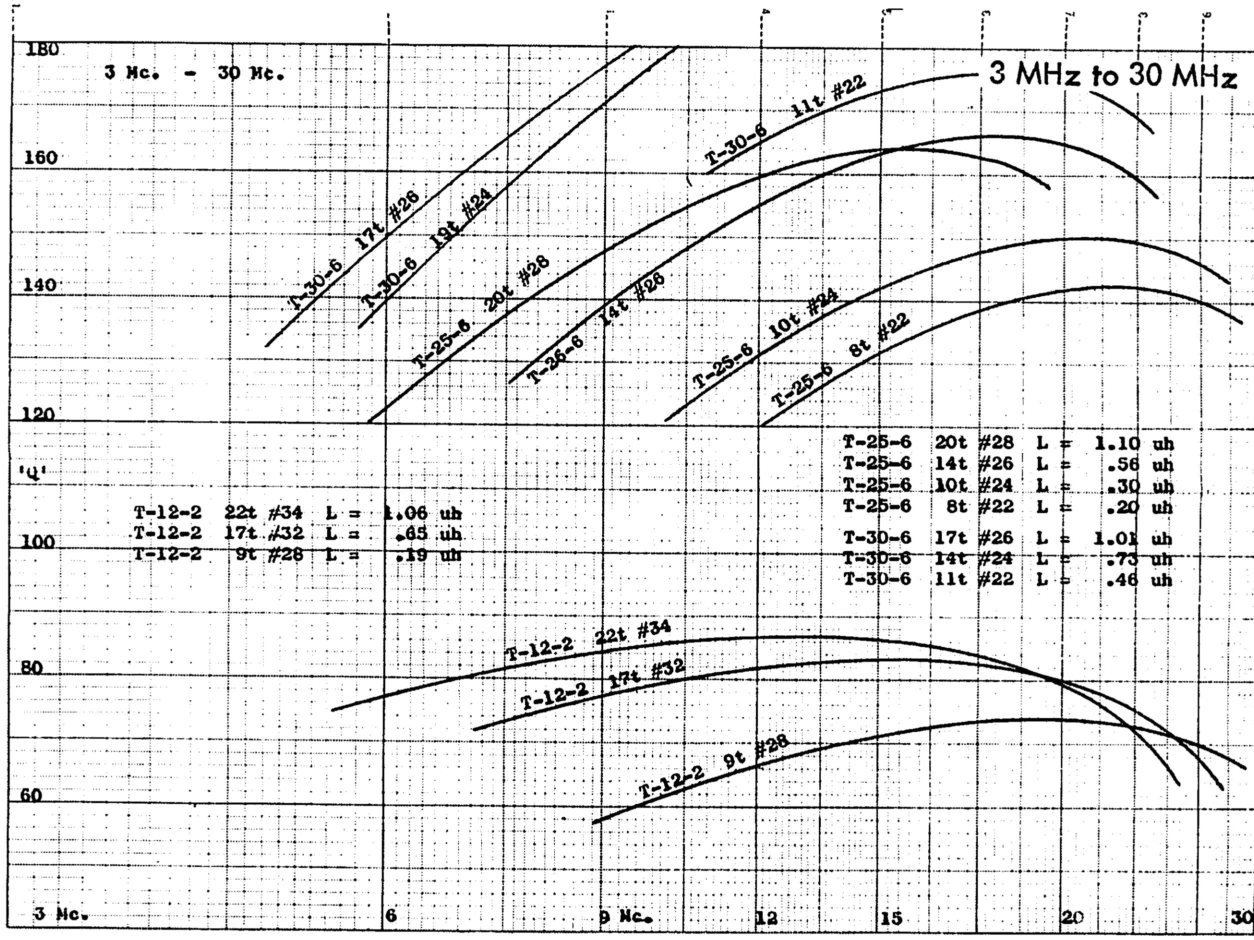
IRON-POWDER TOROIDAL CORES

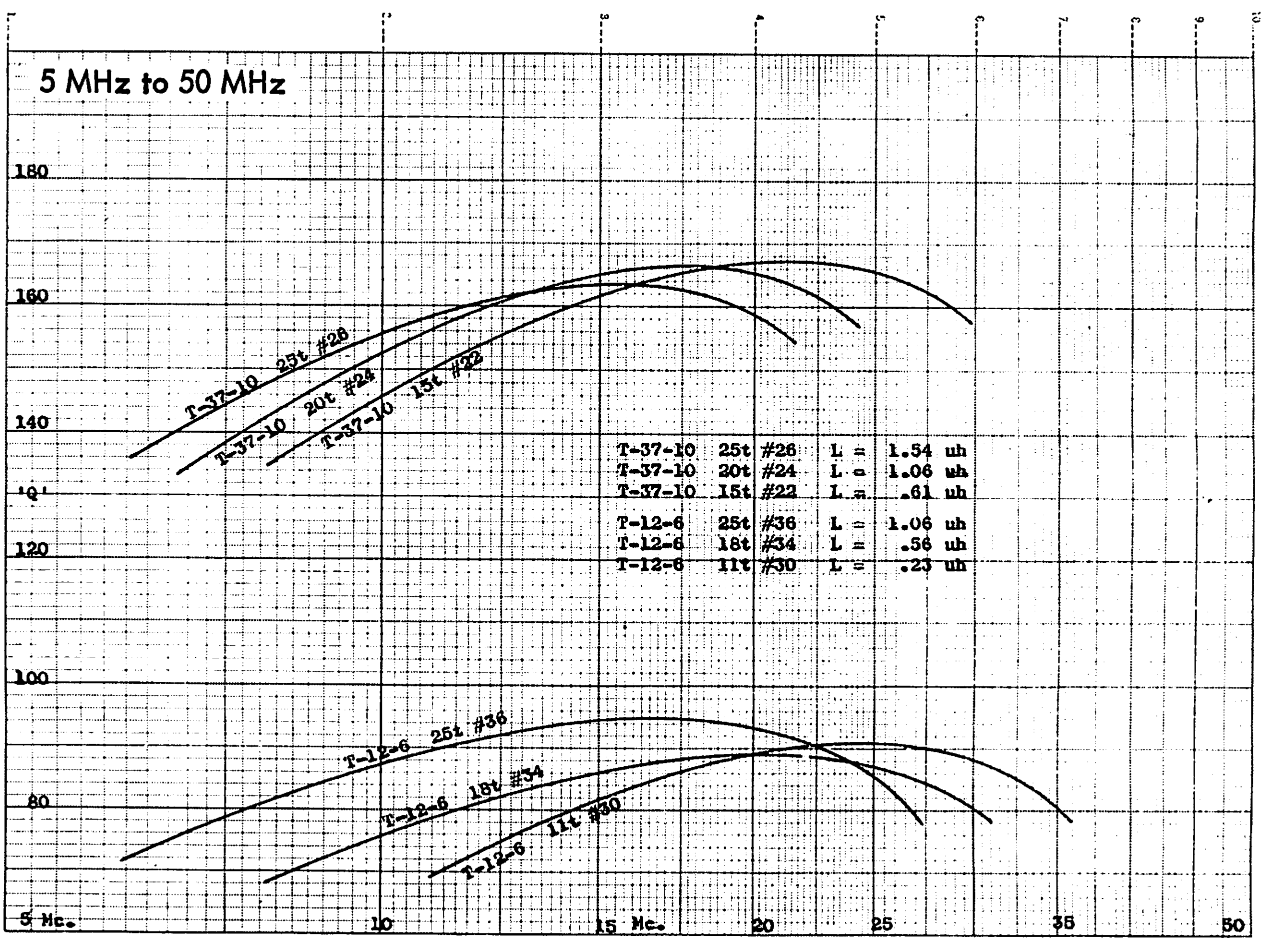
Q—CURVES





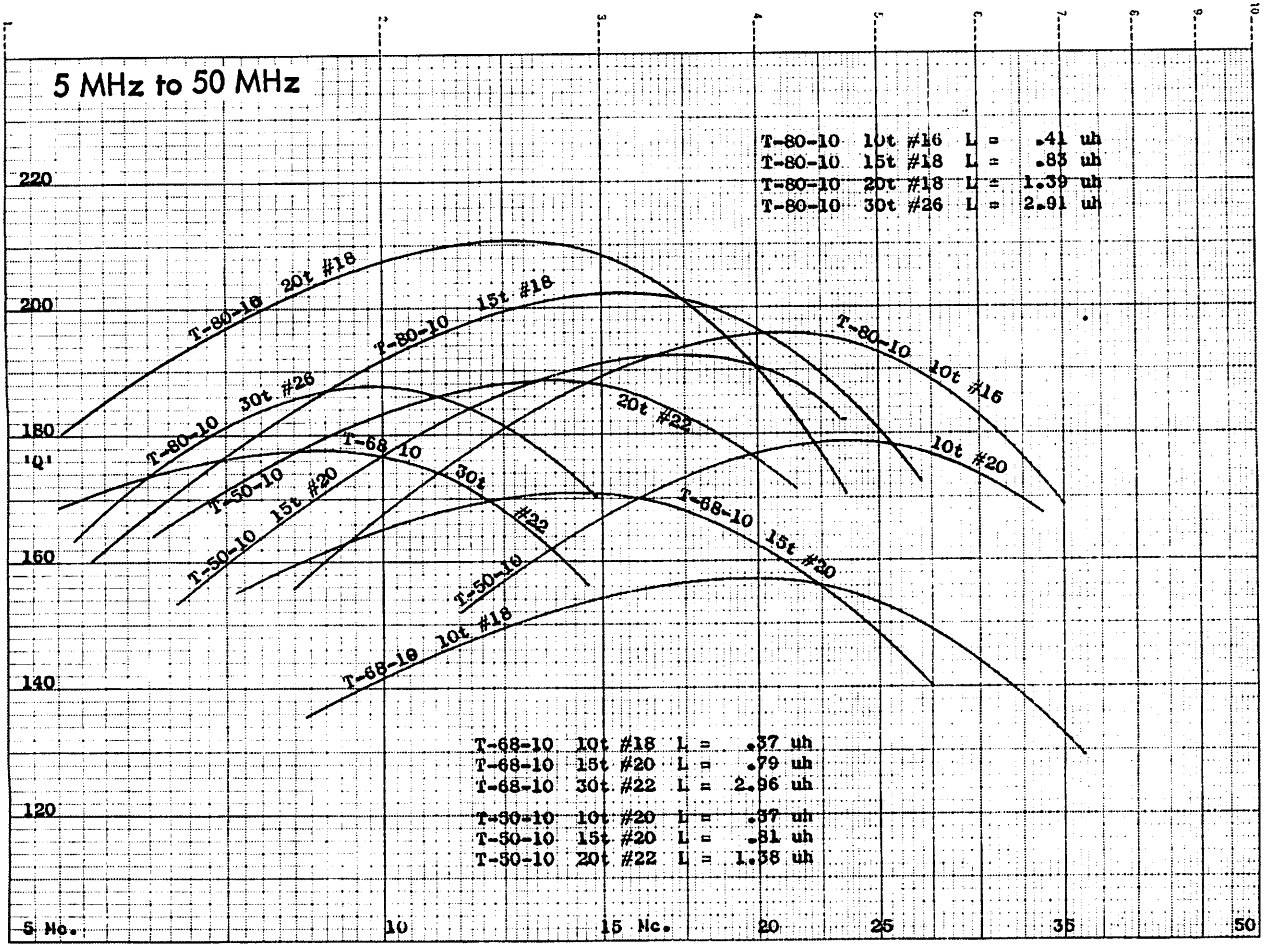
IRON-POWDER TOROIDAL CORES

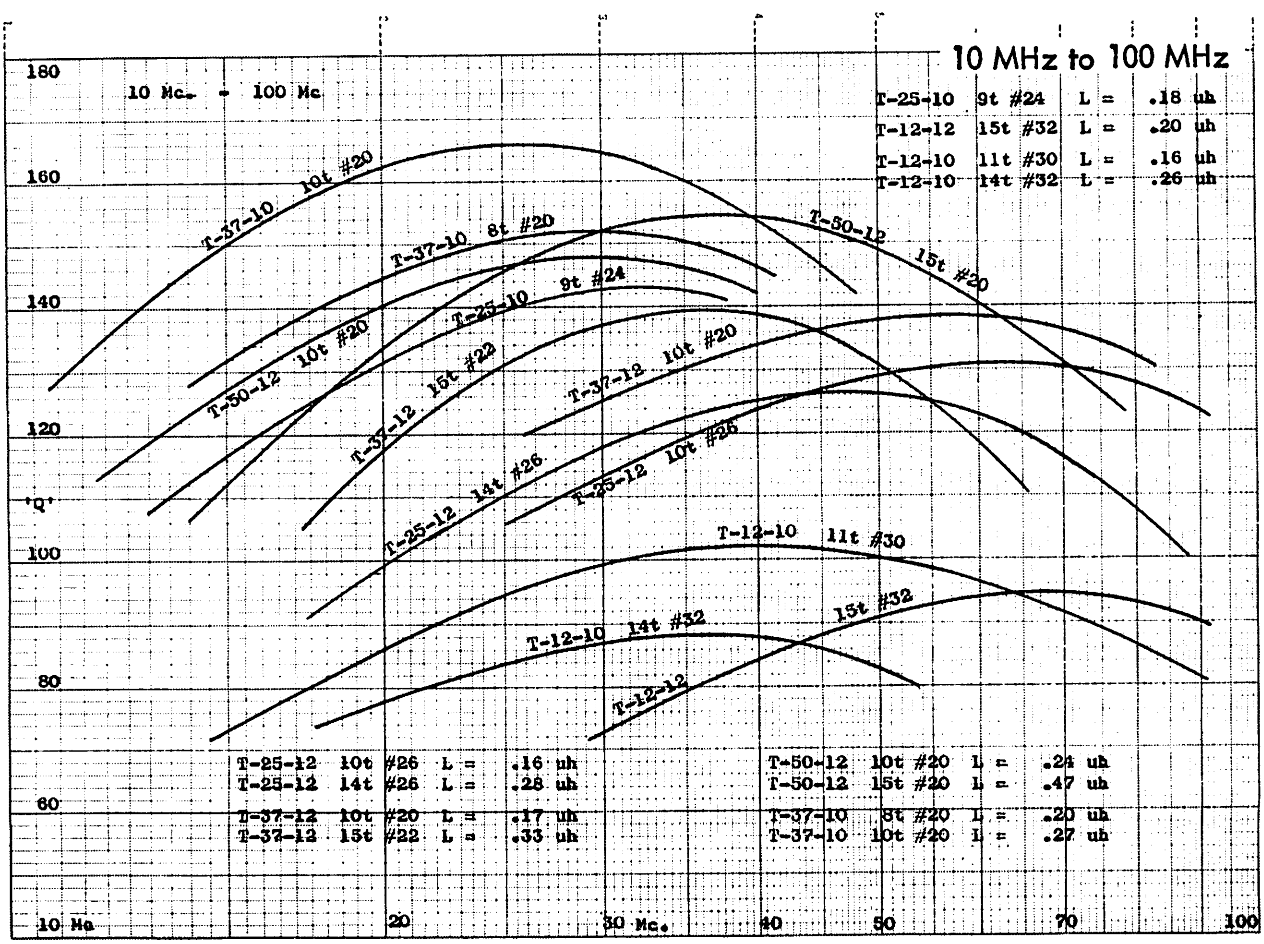




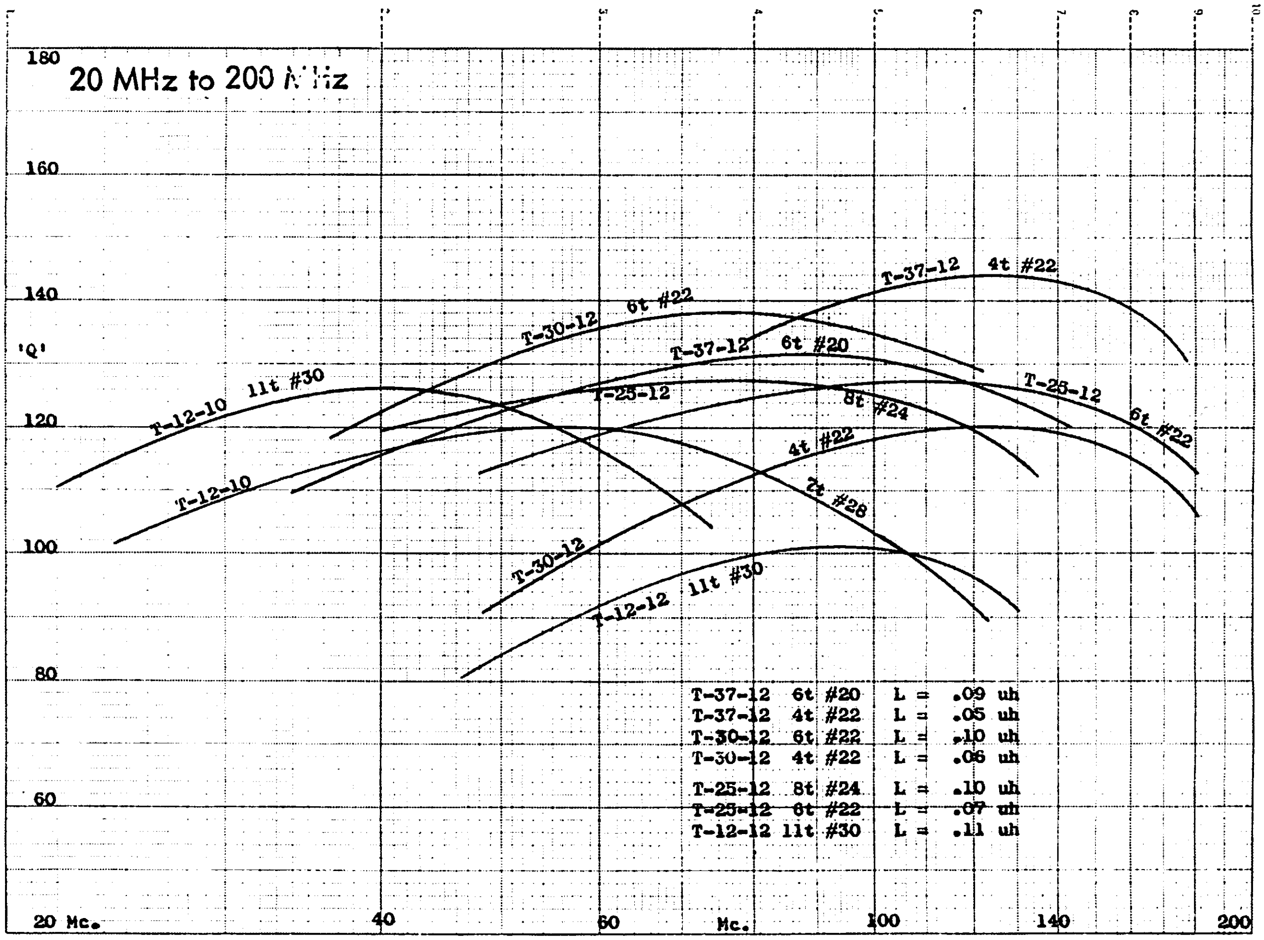
IRON-POWDER TOROIDAL CORES

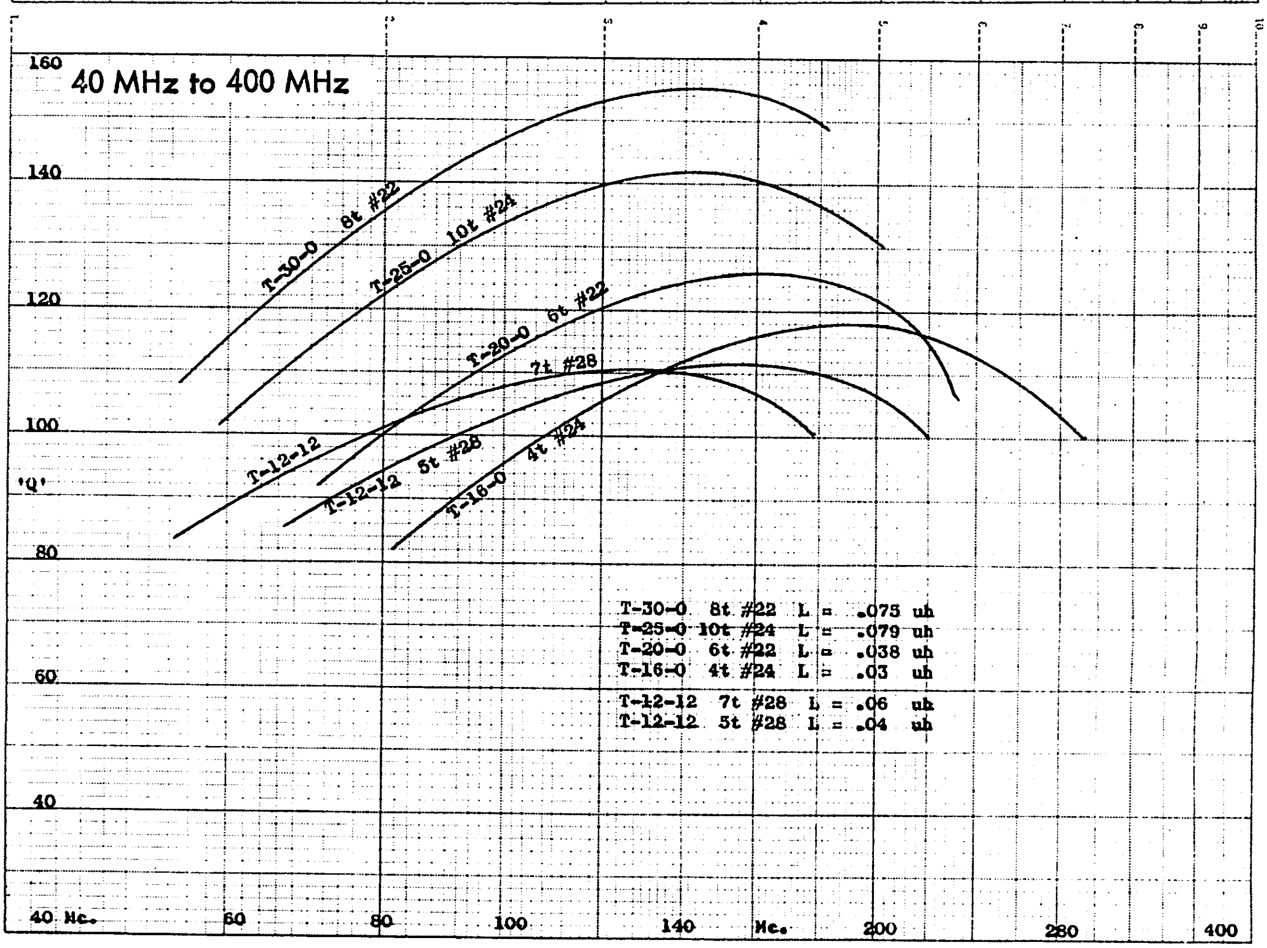
Q—CURVES





IRON-POWDER TOROIDAL CORES





INDUCTANCE CHARTS

Iron Powder Toroids

IRON POWDER TOROIDAL CORES

MATERIAL #0 Inductance (uh) vs. Size, Material and Number of Turns

Turns>	10	20	30	40	50	60	70	80	90	100	110	120	130	140
Size														
T-106	.19	.76	1.7	3.0	4.8	6.8	9.3	12	15	19	23	27	32	37
T-94	.10	.40	.90	1.7	2.7	3.8	5.2	6.8	8.6	10.	13	15	18	21
T-80	.08	.34	.77	1.4	2.1	3.0	4.2	5.4	6.9	8.5	10	12	14	-
T-68	.07	.30	.67	1.2	1.9	2.7	3.7	4.8	6.0	7.5	-	-	-	-
T-50	.06	.26	.57	1.0	1.6	2.3	3.1	4.1	-	-	-	-	-	-
T-37	.05	.20	.44	.7	1.2	-	-	-	-	-	-	-	-	-
T-25	.04	.18	.41	-	-	-	-	-	-	-	-	-	-	-
T-20	.03	.14	-	-	-	-	-	-	-	-	-	-	-	-
T-16	.03	.12	-	-	-	-	-	-	-	-	-	-	-	-
T-12	.03	-	-	-	-	-	-	-	-	-	-	-	-	-

IRON POWDER TOROIDAL CORES

MATERIAL #1 Inductance (uh) vs. Size, Material and Number of Turns

Turns>	10	20	30	40	50	60	70	80	90	100	110	120	130	140
Size														
T-106	3.2	13	29	52	81	117	159	208	263	325	393	468	549	637
T-94	1.6	6.4	14	25	40	57	78	102	130	160	194	230	270	304
T-80	1.2	4.6	10	18	28	41	56	73	93	115	139	166	194	-
T-68	1.2	4.6	10	18	28	41	56	73	93	115	139	166	194	-
T-50	1.0	4.0	9	16	25	36	49	64	-	-	-	-	-	-
T-37	.8	3.2	7	13	20	-	-	-	-	-	-	-	-	-
T-25	.7	2.8	6	-	-	-	-	-	-	-	-	-	-	-
T-20	.5	2.0	-	-	-	-	-	-	-	-	-	-	-	-
T-16	.4	1.7	-	-	-	-	-	-	-	-	-	-	-	-
T-12	.4	-	-	-	-	-	-	-	-	-	-	-	-	-

IRON POWDER TOROIDAL CORES

MATERIAL # 2 Inductance (uh) vs. Size, Material and Number of Turns

Turns>	10	20	30	40	50	60	70	80	90	100	110	120	130	140
Size														
T-106	1.4	5	12	22	34	49	66	86	109	135	163	194	228	265
T-94	.8	3	8	13	21	30	41	54	68	84	101	120	131	142
T-80	.6	2	5	9	14	20	27	35	45	55	66	79	93	-
T-68	.6	2	5	9	15	21	29	38	48	59	-	-	-	-
T-50	.5	2	2	8	12	18	24	31	-	-	-	-	-	-
T-37	.4	2	4	6	10	-	-	-	-	-	-	-	-	-
T-25	.3	1	3	-	-	-	-	-	-	-	-	-	-	-
T-20	.3	1	-	-	-	-	-	-	-	-	-	-	-	-
T-16	.2	-	-	-	-	-	-	-	-	-	-	-	-	-
T-12	.1	-	-	-	-	-	-	-	-	-	-	-	-	-

INDUCTANCE CHARTS

Iron Powder Toroids

IRON POWDER TOROIDAL CORES														
MATERIAL #3	Inductance (uh) vs. Size, Material and Number of Turns													
Turns>	10	20	30	40	50	60	70	80	90	100	110	120	130	140
Size														
T-106	5	18	41	72	113	182	221	288	365	450	545	648	761	882
T-94	2	10	22	40	62	89	121	159	200	248	300	357	419	486
T-80	2	7	16	29	45	65	88	115	146	180	218	259	304	-
T-68	3	8	18	31	49	70	96	125	158	185	-	-	-	-
T-50	2	7	16	26	44	63	86	112	-	-	-	-	-	-
T-37	1	5	9	-	-	-	-	-	-	-	-	-	-	-
T-25	1	4	9	-	-	-	-	-	-	-	-	-	-	-
T-20	.9	4	-	-	-	-	-	-	-	-	-	-	-	-
T-16	.6	2	-	-	-	-	-	-	-	-	-	-	-	-
T-12	.6	-	-	-	-	-	-	-	-	-	-	-	-	-

IRON POWDER TOROIDAL CORES														
MATERIAL #6	Inductance (uh) vs. Size, Material and Number of Turns													
Turns>	10	20	30	40	50	60	70	80	90	100	110	120	130	140
Size														
T-106	1.1	5	10	19	30	42	57	74	94	116	140	167	196	227
T-94	.7	3	6	11	18	25	34	45	57	70	85	100	118	137
T-80	.5	2	4	7	11	16	22	29	36	45	54	64	76	-
T-68	.5	2	4	7	11	17	23	30	38	47	-	-	-	-
T-50	.4	2	3	6	10	14	20	26	-	-	-	-	-	-
T-37	.4	1	3	5	7	-	-	-	-	-	-	-	-	-
T-25	.3	1	2	-	-	-	-	-	-	-	-	-	-	-
T-20	.2	.8	1	-	-	-	-	-	-	-	-	-	-	-
T-16	.2	-	-	-	-	-	-	-	-	-	-	-	-	-
T-12	.1	-	-	-	-	-	-	-	-	-	-	-	-	-

IRON POWDER TOROIDAL CORES														
MATERIAL #10	Inductance (uh) vs. Size, Material and Number of Turns													
Turns>	10	20	30	40	50	60	70	80	90	100	110	120	130	140
Size>														
T-94	.6	2	5	9	15	21	28	37	47	58	70	84	98	113
T-80	.3	1	3	5	8	12	16	21	27	33	40	48	54	-
T-68	.3	1	2	5	8	12	16	20	26	32	-	-	-	-
T-50	.3	1	3	5	8	11	15	20	-	-	-	-	-	-
T-37	.3	1	2	4	6	-	-	-	-	-	-	-	-	-
T-25	.2	.8	2	-	-	-	-	-	-	-	-	-	-	-
T-20	.1	.6	-	-	-	-	-	-	-	-	-	-	-	-
T-16	.1	.5	-	-	-	-	-	-	-	-	-	-	-	-
T-12	.1	-	-	-	-	-	-	-	-	-	-	-	-	-

IRON POWDER TOROIDAL CORES

MATERIAL #15 Inductance (uh) vs. Size, Material and Number of Turns

Turns> / Size	10	20	30	40	50	60	70	80	90	100	110	120	130	140
T-106	4	14	31	55	86	124	169	221	279	345	417	497	583	676
T-94	2	8	18	32	50	72	98	128	162	200	242	288	338	392
T-80	2	7	15	27	43	61	83	109	138	170	206	245	287	-
T-68	2	7	16	29	45	65	88	115	146	180	-	-	-	-
T-50	1	5	12	22	34	49	66	86	-	-	-	-	-	-
T-37	1	4	8	14	23	-	-	-	-	-	-	-	-	-
T-25	1	3	8	-	-	-	-	-	-	-	-	-	-	-
T-20	.5	3	-	-	-	-	-	-	-	-	-	-	-	-
T-16	.5	3	-	-	-	-	-	-	-	-	-	-	-	-
T-12	.5	-	-	-	-	-	-	-	-	-	-	-	-	-

IRON POWDER TOROIDAL CORES

MATERIAL #17 Inductance (uh) vs. Size, Material and Number of Turns

Turns> / Size	10	20	30	40	50	60	70	80	90	100	110	120	130	140
T-94	.3	1	3	5	8	12	16	20	30	32	39	46	54	63
T-80	.2	.8	2	4	6	6	11	14	18	22	27	32	37	-
T-68	.2	.8	2	3	5	7	10	13	17	21	-	-	-	-
T-50	.2	.7	2	3	5	7	9	12	-	-	-	-	-	-
T-37	.1	.6	1	2	4	-	-	-	-	-	-	-	-	-
T-25	.1	.5	1	-	-	-	-	-	-	-	-	-	-	-
T-20	.1	.4	-	-	-	-	-	-	-	-	-	-	-	-
T-16	.08	.3	-	-	-	-	-	-	-	-	-	-	-	-
T-12	.07	-	-	-	-	-	-	-	-	-	-	-	-	-

IRON POWDER TOROIDAL CORES

MATERIAL #26 Inductance (uh) vs. Size, Material and Number of Turns

Turns> / Size	10	20	30	40	50	60	70	80	90	100	110	120	130	140
T-106	9	36	81	144	245	324	441	576	729	900	089	1296	1521	1764
T-94	6	24	53	94	148	212	289	378	478	590	714	850	997	1156
T-80	5	18	41	72	113	162	221	288	365	450	545	648	761	882
T-68	4	17	38	67	105	151	206	269	340	420	508	605	710	823
T-50	3	13	29	51	80	115	157	205	259	320	387	461	541	627
T-37	2.7	11	25	44	69	135	176	223	-	-	-	-	-	-

Amidon Associates: 12033 Otsego Street, North Hollywood, California, 91607

INDUCTANCE CHART - LARGE SIZE IRON POWDERS

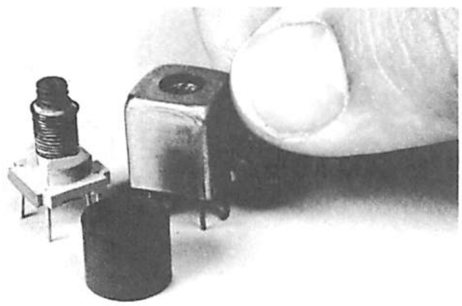
LARGE CORES — Inductance (uh) vs. Size, Material and Number of Turns

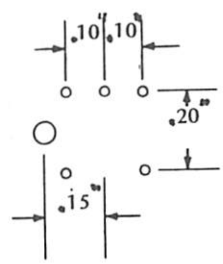
Turns> / Core Number	10	20	30	40	50	60	70	80	90	100	110	120	130
T-400A-26	26	104	324	416	650	936	1274	1664	2106	2600	3146	3744	4394
T-400A-2	4	14	32	21	58	90	130	176	230	292	360	436	518
T-400-26	13	53	119	211	330	475	646	845	1069	1320	1597	1900	2231
T-400-2	2	7	17	27	46	67	91	118	150	185	224	266	313
T-300A-26	16	64	144	256	400	576	784	1024	1296	1600	1936	2304	2704
T-300A-2	2	9	20	36	57	82	118	146	185	228	276	328	385
T-300-26	8	33	74	132	200	297	404	528	668	825	998	1152	1394
T-300-2	1	5	10	18	29	41	56	74	93	115	139	166	194
T-225A-26	16	64	144	256	400	576	784	1024	1296	1600	1936	2304	2704
T-225A-2	2	9	19	34	54	77	105	138	174	215	276	310	385
T-225-26	10	38	86	152	238	342	466	608	770	950	1150	1368	1607
T-225-2	1	5	11	19	30	43	59	79	97	120	145	173	203
T-225-3	4	17	38	68	106	153	208	272	344	425	514	612	718
T-225-6	1	4	9	16	25	36	49	64	81	100	121	144	169
T-200A-26	16	62	136	248	388	558	760	992	1256	1550	1875	2418	2619
T-200A-1	5	18	41	73	114	164	223	291	369	455	551	655	764
T-200A-2	2	9	19	35	55	78	107	140	177	218	264	314	368
T-200A-3	5	18	41	74	115	165	225	294	373	460	557	662	777
T-200A-6	2	7	16	29	45	65	88	115	146	180	218	259	304
T-200-26	9	36	81	143	224	322	439	573	725	895	1082	1289	1513
T-200-1	3	10	23	40	63	90	123	160	203	250	303	360	423
T-200-2	1	5	11	19	30	43	59	79	97	120	145	173	203
T-200-3	4	17	38	68	106	153	208	272	344	425	514	612	718
T-200-6	1	4	9	16	25	36	49	64	81	100	121	144	169
T-184-26	16	66	148	262	410	590	804	1049	1328	1640	1984	2362	2772
T-184-1	5	20	45	80	125	180	245	320	405	500	605	720	845
T-184-2	2	10	22	38	60	86	118	154	194	240	290	396	406
T-184-3	7	29	65	115	180	259	353	461	583	720	871	1039	1217
T-184-6	2	8	18	31	49	70	96	125	158	195	236	281	330
T-157-26	10	34	87	155	243	349	475	621	786	970	1174	1397	1639
T-157-1	3	13	29	51	80	115	157	205	259	320	387	461	541
T-157-2	1	6	13	22	35	50	69	90	113	140	169	202	237
T-157-3	4	17	38	67	105	151	206	269	340	420	508	605	710
T-157-6	1	5	10	18	29	41	56	74	93	115	139	166	194
T-157-15	4	14	32	58	90	130	176	230	292	360	436	518	608
T-130-26	8	31	71	126	196	283	385	502	636	785	950	1130	1327
T-130-1	2	8	18	32	50	72	98	128	162	200	242	288	334
T-130-2	1	4	10	18	28	40	54	70	89	110	133	158	186
T-130-3	4	13	36	56	88	127	172	224	284	350	424	504	592
T-130-6	1	4	9	15	24	35	47	61	78	96	116	138	162
T-130-15	3	10	23	40	63	90	123	160	203	250	303	360	423

Iron Powder Shielded Coil Forms

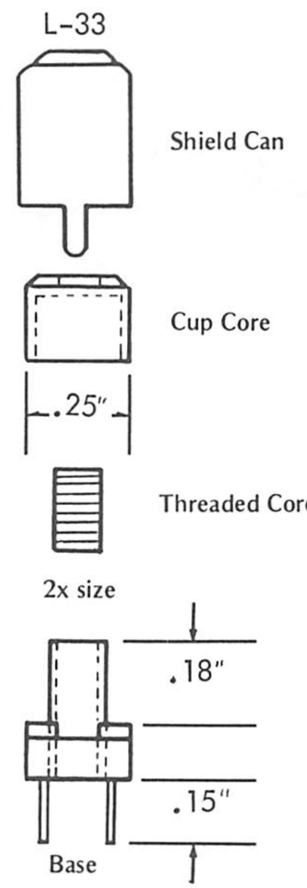
Adjustable/ Slug Tuned

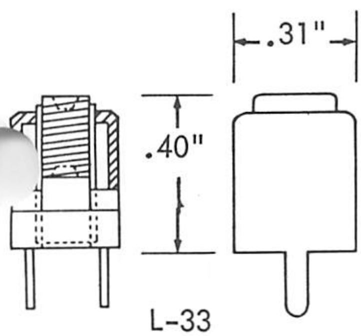
L-33 Coil Forms (Specify material)





pin spacing





Sub miniture size
Slug tuning
Copper shield, tin plated
Easy to wind
Good Q
Freq. range 10 KHz - 200 MHz
Inductance range .08 - 180 uh

Part number	Frequency range (MHz)	A_L (uh/100t) at max L	L ratio max to min	Typical Winding (mid-freq.) Wire	Turns	L(uh)	Qmax
L-33-1	0.30 - 1.0	76	1.7 - 1	3/44	75	42.5	80
L-33-2	1.00 - 10.0	68	1.5 - 1	9/44	40	10.9	90
L-33-3	0.01 - 0.5	80	1.8 - 1	3/44	150	180	70
L-33-6	10.00 - 50.0	60	1.5 - 1	26	7	0.36	100
L-33-10	25.00 - 100.0	54	1.4 - 1	26	5	0.18	120
L-33- 17	50.00 - 200.0	48	1.3 - 1	26	3	0.08	130

Solid magnet wire may be substituted for the Litz wire, but somewhat lower Q may result.

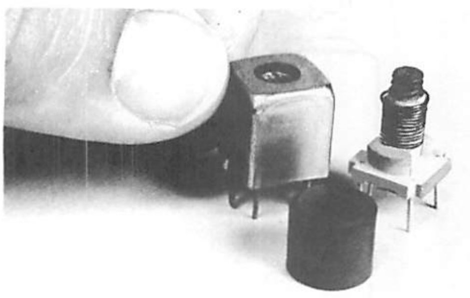
Most efficient when tuning slug is set at maximum L. For tuning flexibility calculate so that slug will be about 90% maximum L when at operating frequency.

$$\text{Turns} = 100\sqrt{\frac{\text{desired 'L' (uh)}}{90\%\ A_L\ \text{(uh/100 turns)}}}$$

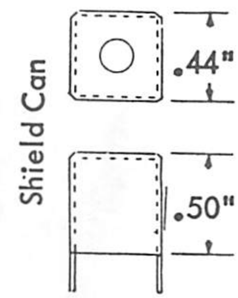
Iron Powder Shielded Coil Forms

Adjustable/ Slug Tuned

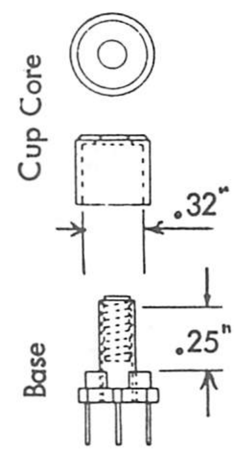
L-43 Coil Forms (Specify material)

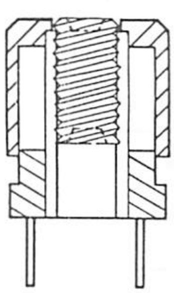


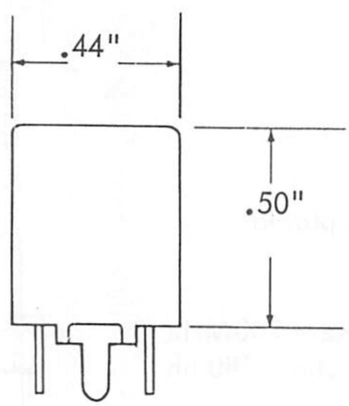
L-43



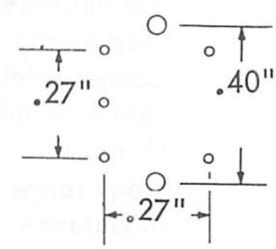
- Miniature in size
- Slug tuning
- Copper shield can, tin plated
- Easy to wind
- Good Q
- Frequency range .2 to 200 MHz.
- Inductance range .02 to 700 uh.







L-43



pin spacing

Part number	Frequency range (MHz)	A_L (uh/100t) at max L	L ratio max to min	Typical Winding (mid-freq.) Wire	Turns	L(uh)	Qmax
L-43-1	0.30 - 1.0	115	1.6 - 1	5/44	149	230	110
L-43-2	1.00 - 10.0	98	1.6 - 1	9/44	21	4.0	120
L-43-3	0.01 - 0.5	133	1.8 - 1	3/44	223	600	90
L-43-6	10.00 - 50.0	85	1.4 - 1	26	6	0.30	130
L-43-10	25.00 - 100.0	72	1.3 - 1	24	5	0.14	150
L-43- 17	50.00 - 200.0	56	1.2 - 1	22	3	0.05	200

Solid magnet wire may be substituted for the Litz wire, but somewhat lower Q may result.

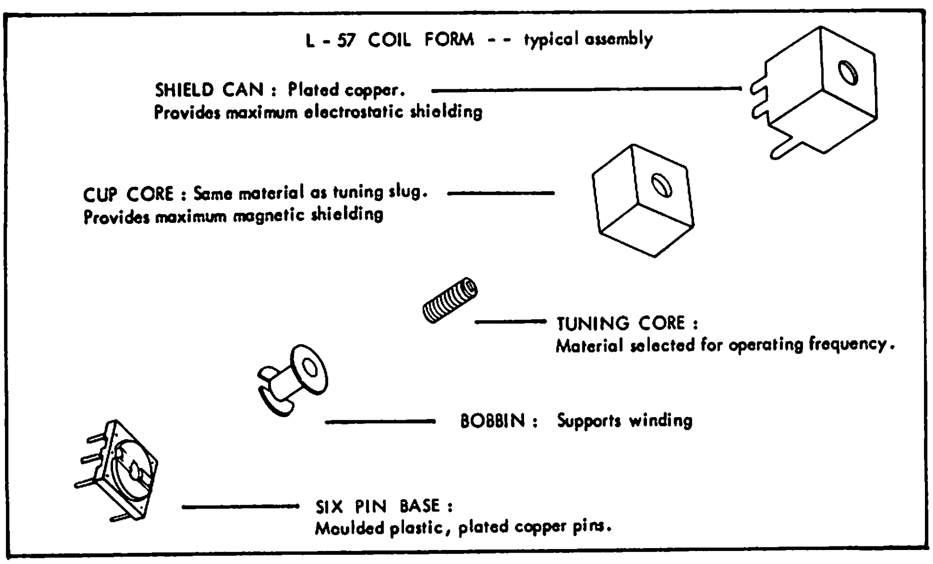
Most efficient when tuning slug is set at maximum L.
For tuning flexibility calculate so that slug will be about 90% maximum L when at operating frequency.

$$\text{Turns} = 100\sqrt{\frac{\text{desired 'L' (uh)}}{90\%\ A_L\ \text{(uh/100 turns)}}}$$

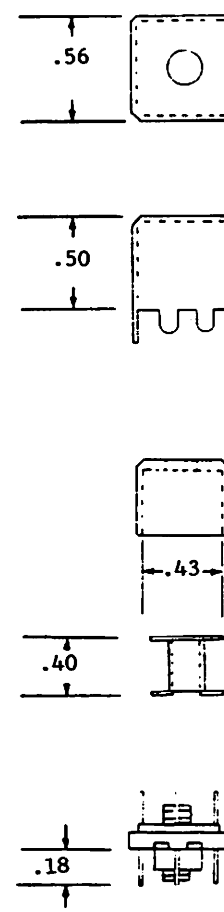
Iron Powder Shielded Coil Forms
Slug Tuning

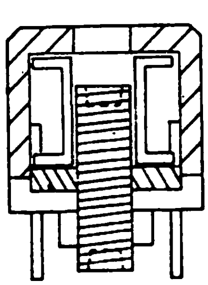
L-57 Shielded Coil Form

Part Number	Frequency Range	A_L (uh/100 t) (at max. Q)	Color Code	Tuning Range
L-57-1	.30 MHz - 1.0 MHz	175 uh	Blue	3/1
L-57-2	1.00 MHz - 10.0 MHz	125 uh	Red	2/1
L-57-3	.01 MHz - .5 MHz	204 uh	Gray	3/1
L-57-6	10.00 MHz - 50.0 MHz	115 uh	Yellow	2/1
L-57-10	25.00 MHz - 100.0 MHz	100 uh	Black	2/1
L-57-17	50.00 MHz - 150.0 MHz	67 uh	Violet	1.5/1



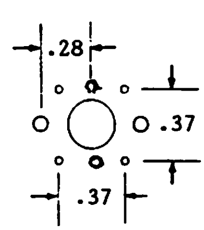
L-57





L-57

1. Available in materials 1, 2, 3, 6, 10, and 12
2. Can be tuned from both top and bottom
3. Furnished with six - pin base to accommodate center tapped coils.



Terminal Spacing

Most efficient when tuning slug is set at maximum L. For tuning flexibility, calculate so that slug will be about 90% maximum L when at operating frequency.

$$\text{Turns} = 100\sqrt{\frac{\text{desired L (uh)}}{90\%\ A_L \text{ value (uh/100 t)}}}$$

IRON POWDER TOROIDAL CORES
For
DC CHOKES and AC LINE FILTERS

For many years Iron Powder has been used as the core material for RF inductors and transformers when stability and high 'Q' are of primary concern. Because of the growing need for energy storage inductors for noise filtering, new materials have been developed for these applications

High 'Q' inductors are no longer required, in fact low 'Q' actually helps damp high frequency oscillations. The #26 Iron Powder material is ideally suited for these applications since it combines low 'Q', good frequency response, and high energy capabilities.

Energy storage , expressed in microjuoles, is calculated by multiplying one-half the inductance in uh times the current in amperes squared. The amount of energy that can be stored in a given inductor is limited either by saturation of the core material or temperature rise of the wound unit, resulting in copper loss and/or core loss.

In typical DC chokes, the AC ripple flux is normally small in comparison to the DC component. Since the DC flux does not generate core loss, our primary concern becomes saturation and copper loss. The DC saturation characteristics of the #26 material are shown in Fig. A on the following page.

Using this information, DC energy storage curves have been developed as shown in the chart on the 2nd following page. A table of energy storage limits vs. temperature rise is included in the chart. The table at the bottom of the page is for single layer winding.

In 60 Hz. line filter applications, the high frequency to be filtered falls into two categories: (1) Common-mode noise and (2) Differential-mode noise. The common-mode noise is in relation to earth ground and is common to both lines. Differential mode noise is the noise between the two lines.

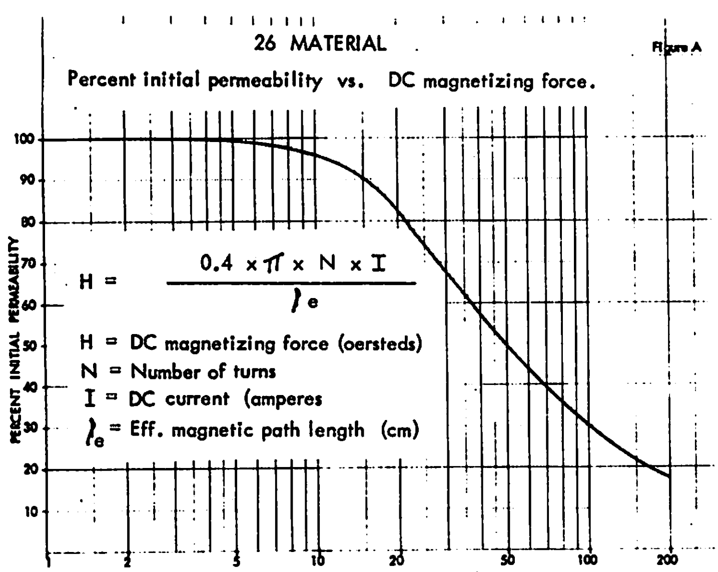
The Common-mode noise filter is usually constructed on a high permeability ferrite type core with a bifilar type winding. This type of winding allows the 60 Hz. flux generated by each line to cancel within the core, thus avoiding saturation. If the #26 Iron Powder material were to be used, the large core size necessary to accommodate the required number of wire turns for the required inductance makes this option unattractive.

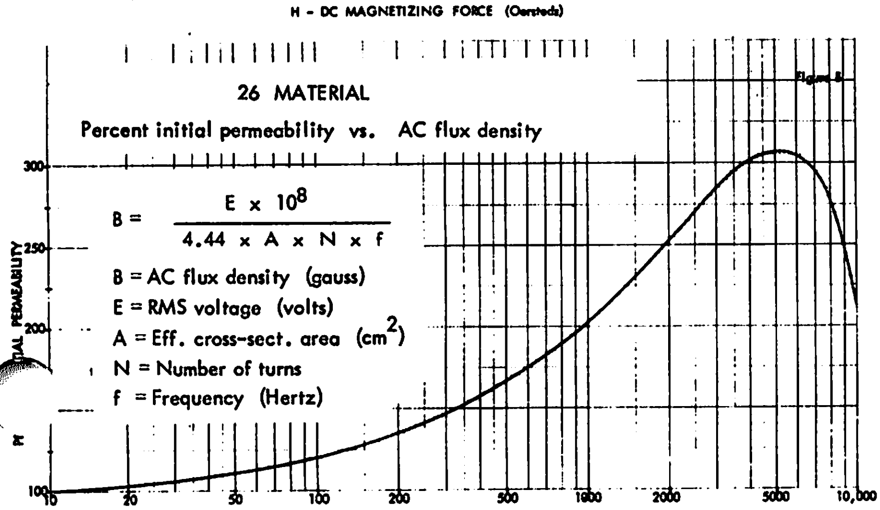
The Differential-mode filters must be able to support a significant amount of 60Hz. flux without saturating. The AC saturation characteristics of the #26 material (Fig. B) and core loss information (Fig. C) can be seen on the following page. Notice how the permeability initially increases with AC excitation. This effect allows greater energy storage in 60 Hz. applications.

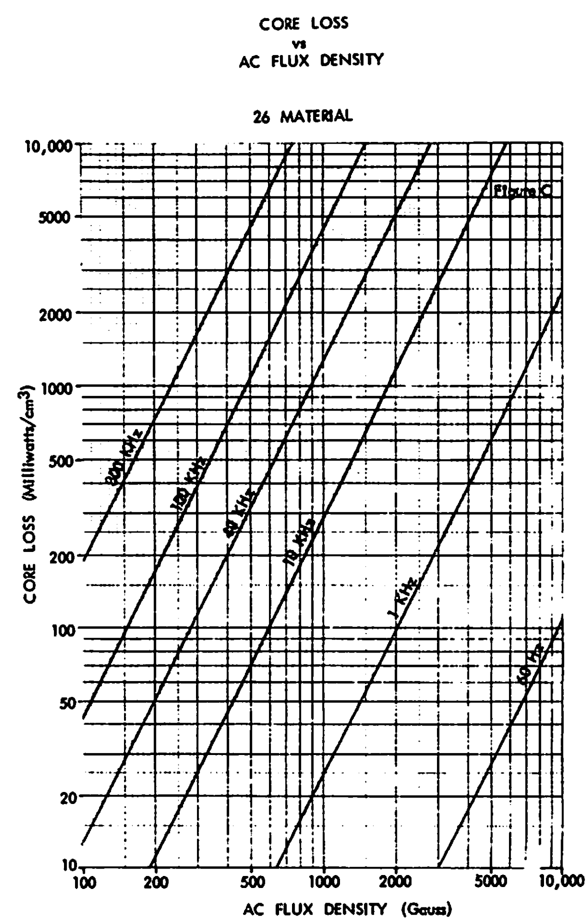
Energy storage curves have been developed for line filter applications as shown on the 3rd following page. The energy storage limit table is now taking into account both the core and the copper loss. In order to guarantee a minimum inductance over a wide current range, the design engineer may wish to calculate the required turns based on the listed A_L value of the core.

Cores for DC Chokes and AC Line Filters

Material 26		Permeability 75		DC to 1 MHz (Low 'Q')		Yellow and White	
Core number	O.D. (inches)	I.D. (inches)	Hgt. (inches)	l_e (cm)	A_e (cm)^2	V_e (cm)^3	A_L Value uh/100 turns
T-30-26	.307	.151	.128	1.83	.065	.119	325
T-37-26	.375	.205	.128	2.32	.070	.162	275
T-44-26	.440	.229	.159	2.67	.107	.286	360
T-50-26	.500	.303	.190	3.03	.121	.367	320
T-68-26	.690	.370	.190	4.24	.196	.831	420
T-80-26	.795	.495	.250	5.15	.242	1.246	450
T-94-26	.942	.560	.312	6.00	.385	2.310	590
T-106-26	1.060	.570	.437	6.50	.690	4.485	900
T-130-26	1.300	.780	.437	8.29	.730	6.052	785
T-157-26	1.570	.950	.570	10.05	1.140	11.457	970
T-184-26	1.840	.950	.710	11.12	2.040	22.685	1640
T-200-26	2.000	1.250	.550	12.97	1.330	17.250	895
T-200A-26	2.000	1.250	1.000	12.97	2.240	29,050	1525
T-225 -26	2.250	1.405	.550	14.56	1.508	21.956	950
T-225A-26	2.250	1.485	1.000	14.56	2.730	39.749	1600
T-300 -26	3.058	1.925	.500	19.83	1.810	35.892	800
T-300A-26	3.048	1.925	1.000	19.83	3.580	70.991	1600
T-400 -26	4.000	2.250	.650	24.93	3.660	91.244	1300
T-400A-26	4.000	2.250	1.300	24.93	7.432	185.280	2600
T-520 -26	5.200	3.080	.800	33.16	5.460	181.000	1460

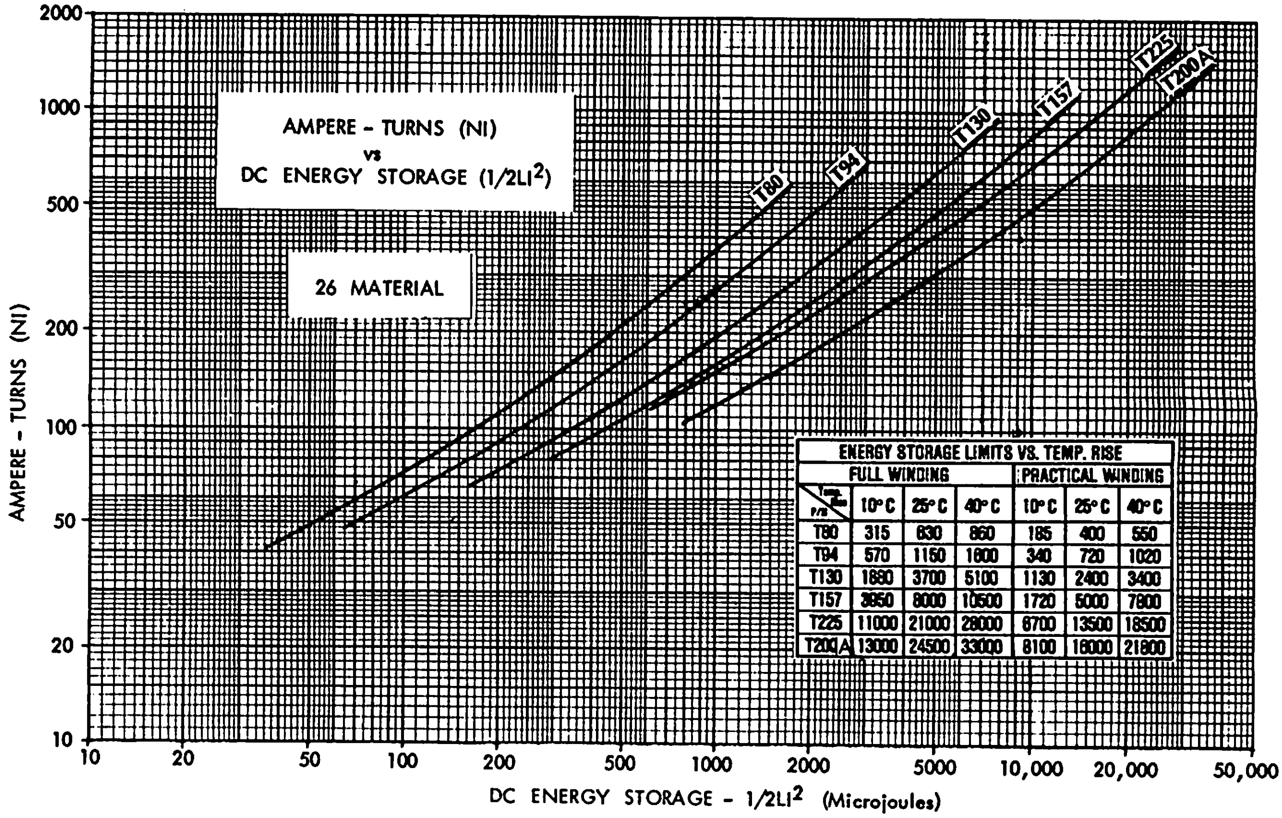






Iron Powder Toroidal Cores

DC Chokes



ENERGY STORAGE LIMITS VS. TEMP. RISE						
	FULL WINDING			PRACTICAL WINDING		
Temp. Rise / P/N	10°C	25°C	40°C	10°C	25°C	40°C
T80	315	630	860	185	400	550
T94	570	1150	1600	340	720	1020
T130	1880	3700	5100	1130	2400	3400
T157	3850	8000	10500	1720	5000	7800
T225	11000	21000	28000	6700	13500	18500
T200A	13000	24500	33000	8100	16000	21800

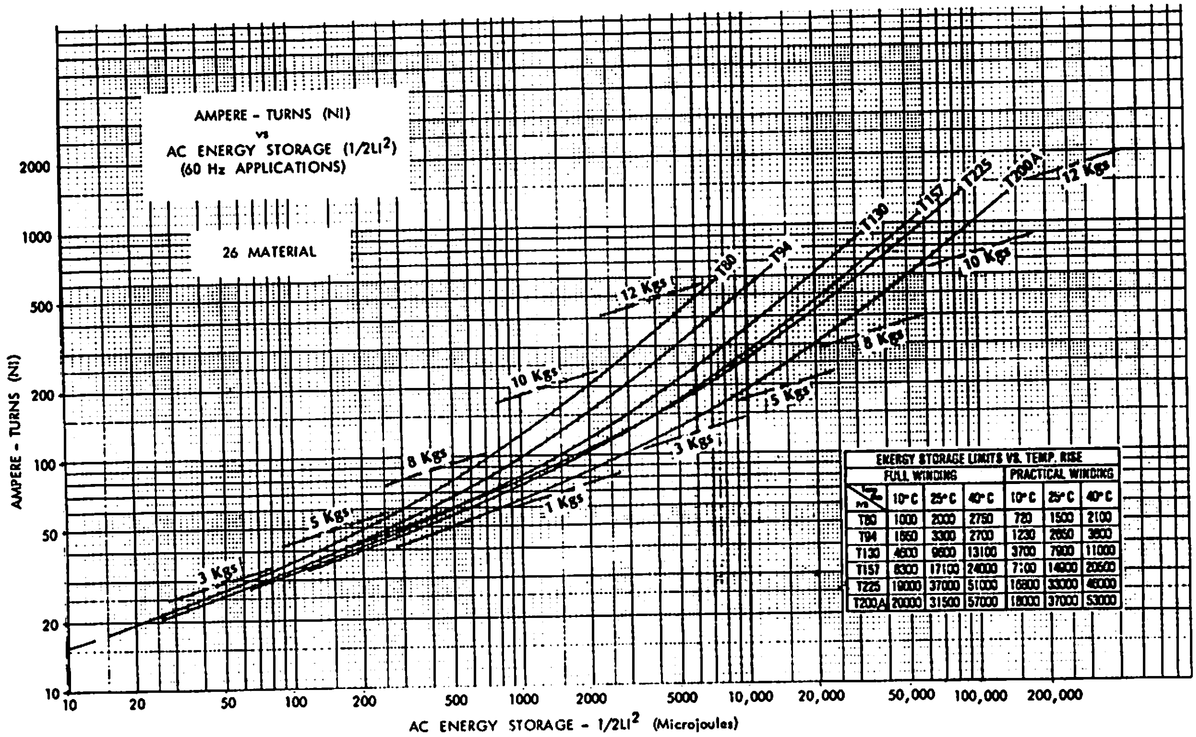
DC Choke Applications (single layer winding)

DC Amps >	1 Amp	2 Amps	4 Amps	6 Amps	10 Amps	15 Amps	20 Amps	30 Amps
Wire size >	28 AWG	24 AWG	21 AWG	19 AWG	16 AWG	14 AWG	12 AWG	10 AWG
Part\/No								
T-37-26*	35 uh 41 turns	13.5 uh 27 turns	4.0 uh 15 turns	1.8 uh 10 turns	.8 uh 7 turns	.38 uh 5 turns	.16 uh 3 turns	.012 uh 1 turn
T-50-26*	92 uh 63 turns	29.0 uh 37 turns	11.3 uh 25 turns	5.5 uh 18 turns	2.1 uh 11 turns	1.1 uh 8 turns	.59 uh 6 turns	.36 uh 5 turns
T-80-26	380 uh 108 turns	130 uh 66 turns	51.3 uh 45 turns	27.8 uh 35 turns	11.2 uh 23 turns	5.7 uh 17 turns	3 uh 12 turns	1.3 uh 8 turns
T-94-26	650 uh 123 turn	220 uh 75 turns	87.5 uh 52 turns	47.2 uh 40 turns	20.0 uh 27 turns	10.2 uh 20 turns	5.3 uh 14 turns	2.6 uh 10 turns
T-130-26	1660 uh 173 turns	575 uh 107 turns	231 uh 75 turns	127 uh 58 turns	55.0 uh 40 turns	28.0 uh 30 turns	16.5 uh 23 turns	10.4 uh 17 turns
T-157-26	3200 uh 213 turns	1100 uh 122 turns	438 uh 93 turns	244 uh 73 turns	106 uh 50 turns	55.6 uh 38 turns	32 uh 29 turns	16.4 uh 22 turns
T-184-26*	5600 uh 213 turns	1950 uh 122 turns	788 uh 93 turns	439 uh 73 turns	190 uh 50 turns	99.6 uh 38 turns	57.5 uh 29 turns	29.3 uh 22 turns
T-225-26	8600 uh 317 turns	2300 uh 198 turns	938 uh 139 turns	528 uh 110 turns	230 uh 77 turns	127 uh 60 turns	72.5 uh 46 turns	40 uh 36 turns
T-300A-26*	22.4 mh 435 turns	7850 uh 272 turns	3120 uh 190 turns	1750 uh 151 turns	760 uh 105 turns	418 uh 82 turns	250 uh 63 turns	129 uh 44 turns
T-400A-26*	51.0 mh 507 turns	17.5 mh 317 turns	7120 uh 223 turns	4000 uh 176 turns	1760 uh 122 turns	951 uh 95 turns	550 uh 73 turns	293 uh 57 turns

Note: * Size not shown on above curve chart. Wire size based on Max. Temp. rise 40°C

Iron Powder Toroidal Cores

AC Line Filters



ENERGY STORAGE LIMITS VS. TEMP. RISE	FULL WINDING			PRACTICAL WINDING		
	10°C	25°C	40°C	10°C	25°C	40°C
T80	1000	2000	2750	720	1500	2100
T94	1650	3300	2700	1230	2650	3800
T130	4600	9600	13100	3700	7900	11000
T157	8300	17100	24000	7:00	14900	20600
T225	19000	37000	51000	16800	33000	46000
T200A	20000	31500	57000	18000	37000	53000

60 Hz. AC Line Filter Applications (single layer winding)

AC Amps >	1 Amp	2 Amps	4 Amps	6 Amps	10 Amps	15 Amps	20 Amps	30 Amps
Wire size >	28 AWG	24 AWG	21 AWG	19 AWG	15 AWG	13 AWG	11 AWG	9 AWG
Part\/No								
T-37 -26*	130 uh 41 turns	50.0 uh 27 turns	15 uh 15 turns	6.7 uh 10 turns	2.4 uh 6 turns	1.1 uh 4 turns	.60 uh 3 turns	.07 uh 1 turn
T-50 -26*	460 uh 63 turns	150 uh 37 turns	58.8 uh 25 turns	26.1 uh 17 turns	9.4 uh 10 turns	4.2 uh 7 turns	2.4 uh 5 turns	1.0 uh 3 turns
T-80 -26	1600 uh 108 turns	550 uh 66 turns	213 uh 45 turns	94.4 uh 30 turns	34.0 uh 18 turns	15.1 uh 12 turns	8.5 uh 9 turns	3.8 uh 6 turns
T-94 -26	2899 uh 123 tunrs	950 uh 75 turns	375 uh 52 turns	156 uh 33 turns	56.0 uh 20 turns	24.9 uh 13 turns	14 uh 10 turns	6.2 uh 7 turns
T-130 -26	7200 uhh 173 turns	2500 uh 107 turns	1000 uh 75 turns	444 uh 50 turns	160 uh 30 turns	71.1 uh 20 turns	40 uh 15 turns	17.8 uh 10 turns
T-157 -26	13.6 mh 213 turns	4650 uh 139 turns	1810 uh 93 turns	806 uh 62 turns	290 uh 37 turns	129 uhh 25 turns	.72.5 uh 18 turns	32.2 uh 12 turns
T-184 -26*	22 mh 213 turns	7750 uh 132 turns	3130 uh 93 turns	1390 uh 62 turns	500 uh 37 turns	222 uh 25 turns	125 uh 18 turns	56.6 uh 12 turns
T-225 -26	26 mh 317 turns	9000 uh 198 turns	3500 uh 139 turns	1940 uh 110 turns	700 uh 66 turns	311 uh 44 turns	175 uh 33 turns	77.8 uh 22 turns
T-300A -26*	84 mh 435 turns	29 mh 272 turns	11.2 mh 190 turns	6390 uh 151 turns	2360 uh 93 turns	1240 uh 72 turns	750 uh 56 turns	356 uh 40 turns
T-400A -26*	180 mh 507 turns	61 mh 317 turns	25.6 mh 223 turns	14.2 mh 176 turns	5300 uh 108 turns	2800 uh 83 turns	1650 uh 65 turns	800 uh 46 turns

Note: * Size not shown on above curve chart. Wire size based on Max. Temp. rise 40^0 C.

POWER CONSIDERATIONS
(IP and Ferrite)

How large a core is needed to handle a certain amount of power ? This is a question often asked, but unfortunately there is no simple answer.

There are several factors involved such as: cross sectional area of the core, core material, turns count, and of course the variables of applied voltage and operating frequency.

Overheating of the coil will usually take place long before saturation in most applications above 100 KHz. Now the question becomes ' How large a core must I have to prevent overheating at a given frequency and power level' ?

Overheating can be caused by both wire and core material losses. Wire heating is affected by both DC and AC currents, while core heating is affected only by the AC content of the signal. With a normal sinewave signal above 100 KHz, both the Iron Powder and Ferrite type cores will first be affected by overheating caused by core losses, rather than saturation.

The following extrapolated AC flux density limits can be used for BOTH Iron Powder and Ferrite type cores as a guide-line to avoid excessive heating. These figures may vary slightly according to material being used.

Frequency:	100 KHz	1 MHz	7 MHz	14 MHz	21 MHz	28 MHz
AC Flux Den.	500 gauss	150 gauss	57 gauss	42 gauss	36 gauss	30 gauss

Operating frequency is one of the most important factors concerning power capability above 100 KHz. A core that works well at 2 MHz. may very well burn up at 30 MHz. with the same amount of drive.

Core saturation, a secondary cause of coil failure, is affected by both AC and DC signals. Saturation will decrease the permeability of the core causing it to have impaired performance or to become inoperative. The safe operating total flux density level for most Ferrite materials is typically 2000 gauss, while Iron Powder materials can tolerate up to 5000 gauss without significant saturation effects.

Iron Powder cores (low permeability) are superior to the Ferrite material cores for high power inductors for this reason: Fewer turns will be required by the Ferrite type core for a given inductance. When the same voltage drop is applied across a decreased number of turns, the flux density will increase accordingly. In order to prevent the flux density from increasing when fewer turns are used, the flux drive will have to be decreased.

Either core material can be used for transformer applications but both will have 'trade-offs'. Ferrite type cores will require fewer turns, will give more impedance per turn and will couple better, whereas the Iron Powder cores will require more turns, will give less impedance per turn, will not couple as well but will tolerate more power and are more stable.

The equation for determining the maximum flux density of a given toroidal core is as follows:

$$B_{max} = \frac{E \times 10^8}{4.44 \times A_e \times N \times F}$$

E_{pk} = applied RMS volts
A_e = cross-sect. area (cm^2)
N = number of wire turns
F = frequency (Hertz)

The safety factor may be increased by using the peak AC voltage in the equation. This is standard practice among many RF engineers who design broadband RF power transformers.

The above equation may be changed as shown below to make it more convenient during calculations of B_{max} at radio frequencies.

$$B_{max} = \frac{E \times 10^2}{4.44 \times A_e \times N \times F}$$

E_{pk} = applied RMS volts
A_e = cross-sect. area (cm^2)
N = number of wire turns
F = frequency (MHz)

The sample calculation below is based on a frequency of 7 MHz, a peak voltage of 25 volts and a primary winding of 15 turns. The cross-sectional area of the sample core is 0.133 cm^2 From previous guidelines we know that the maximum flux density at 7 MHz should be not more than 57 gauss.

$$B_{max} = \frac{25 \times 100}{4.44 \times 0.133 \times 15 \times 7} = 40.3 \text{ gauss}$$

This hypothetical toroid core will have a flux density of 40 gauss according to the above formula and when operated under the above conditions. This is well within the guidelines as suggested above.

Temperature rise can be the result of using an undersized wire gauge for the amount of current involved as well as magnetic action within the core. Both will contribute to the overall temperature rise of the transformer. This can be calculated with the following equation :

$$\text{Temperature Rise } (^\circ C) = \left[\frac{\text{Total Power Dissipation (Milliwatts)}}{\text{Available Surface Area } (cm^2)}\right]^{.833}$$

If the operating temperature (ambient temperature + temperature rise) is more than 100°C when used intermittently, or more than 75°C if used continuously, a larger size core and/or a heavier gauge wire should be selected.

Iron Powder Materials

SATURATION and FLUX DENSITY

The factors affecting the power capability will vary with operating conditions. Core losses are lower at the lower frequencies and lower power levels. Losses will increase rapidly as either the frequency or power level is increased.

Core losses can create overheating, which in turn will affect the saturation point. Maximum flux density can be calculated with the Faraday Law and Amperes Law, both of which are shown below.

Percent Initial Permeability vs. AC Flux Density

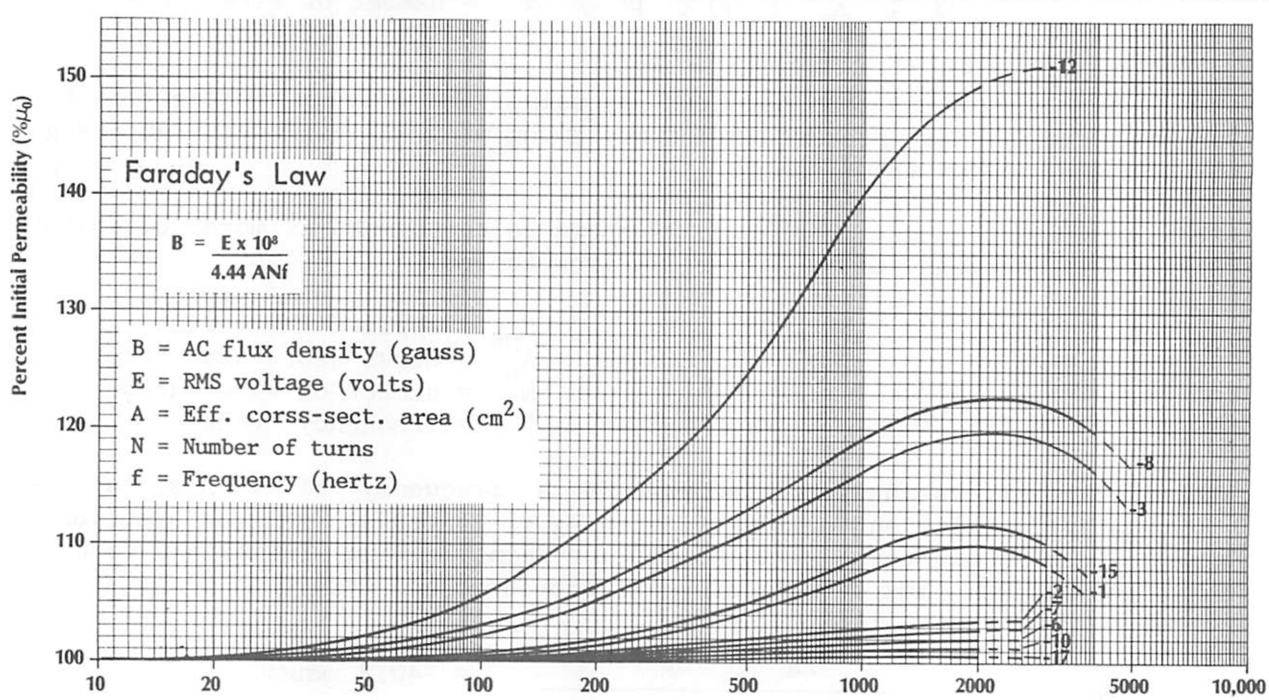


Figure A

Percent Initial Permeability vs. DC Magnetizing Force

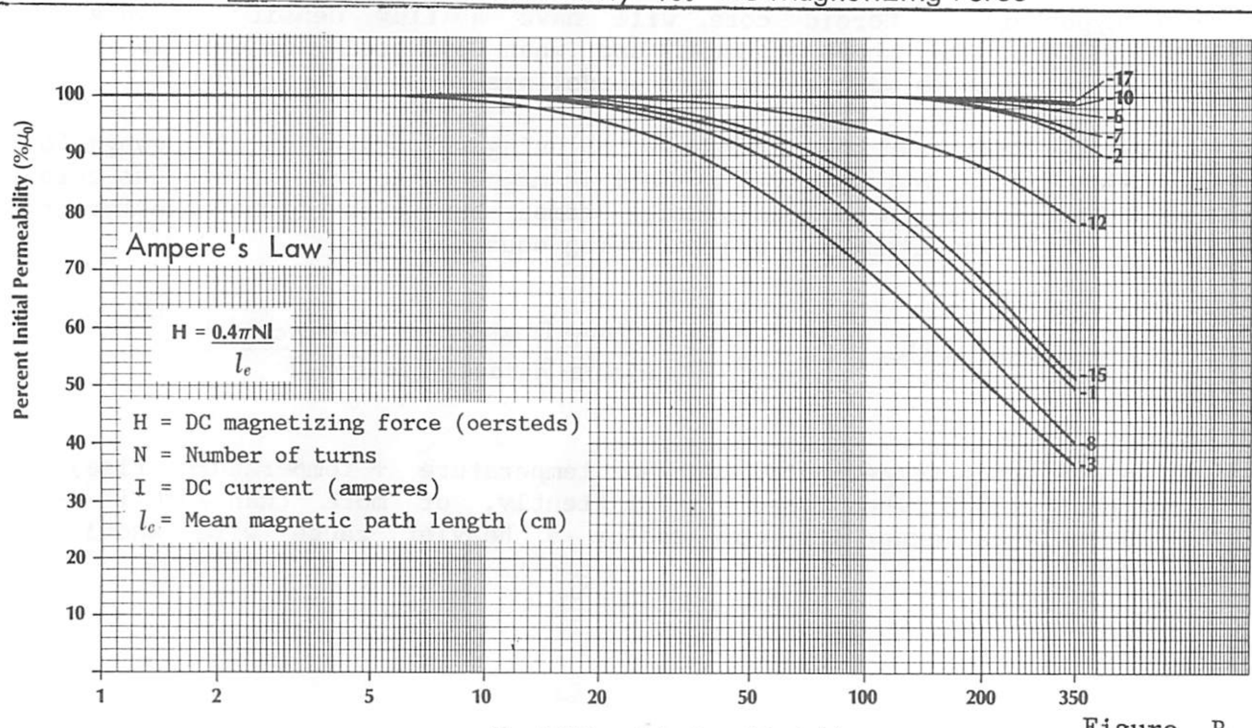


Figure B

Iron Powder Core Loss Characteristics

The Iron Powder Q-curves section of this booklet can be very useful for designing high-Q, low power inductors and transformers, but additional consideration must be given to higher power applications.

Excessive temperature rise due to Iron Powder core loss at high frequencies will occur before saturation and is usually the primary limiting factor in the operation of an Iron Powder core inductor at high frequency.

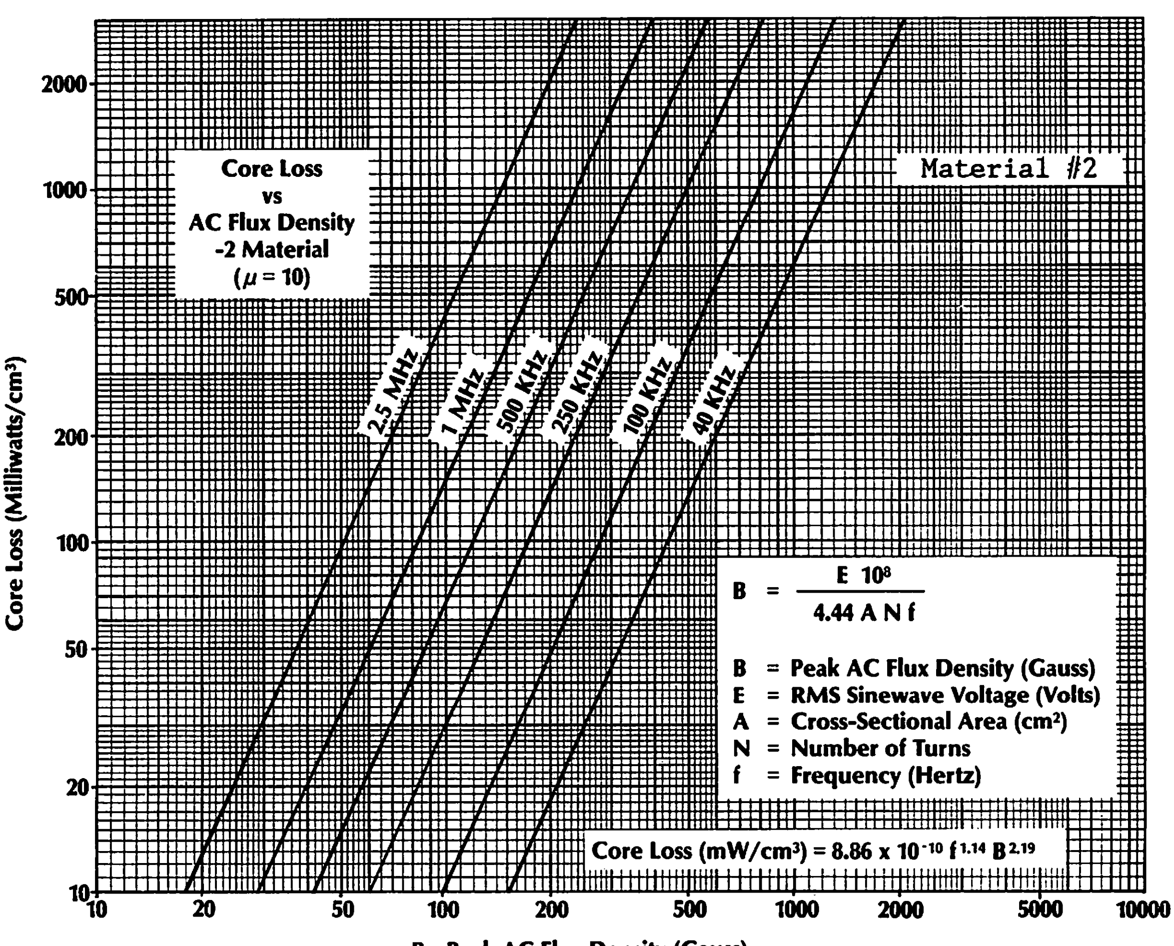
The following charts show core loss information in milliwatts per cubic centimeter of core material as a function of peak AC flux density for various frequencies. The Faraday Law is used to calculate the peak AC flux density. The effective cross-sectional area and volume for each core size can be found on previous pages of this booklet.

The following formula will provide a reasonable approximation for the temperature rise of a core in free standing air.

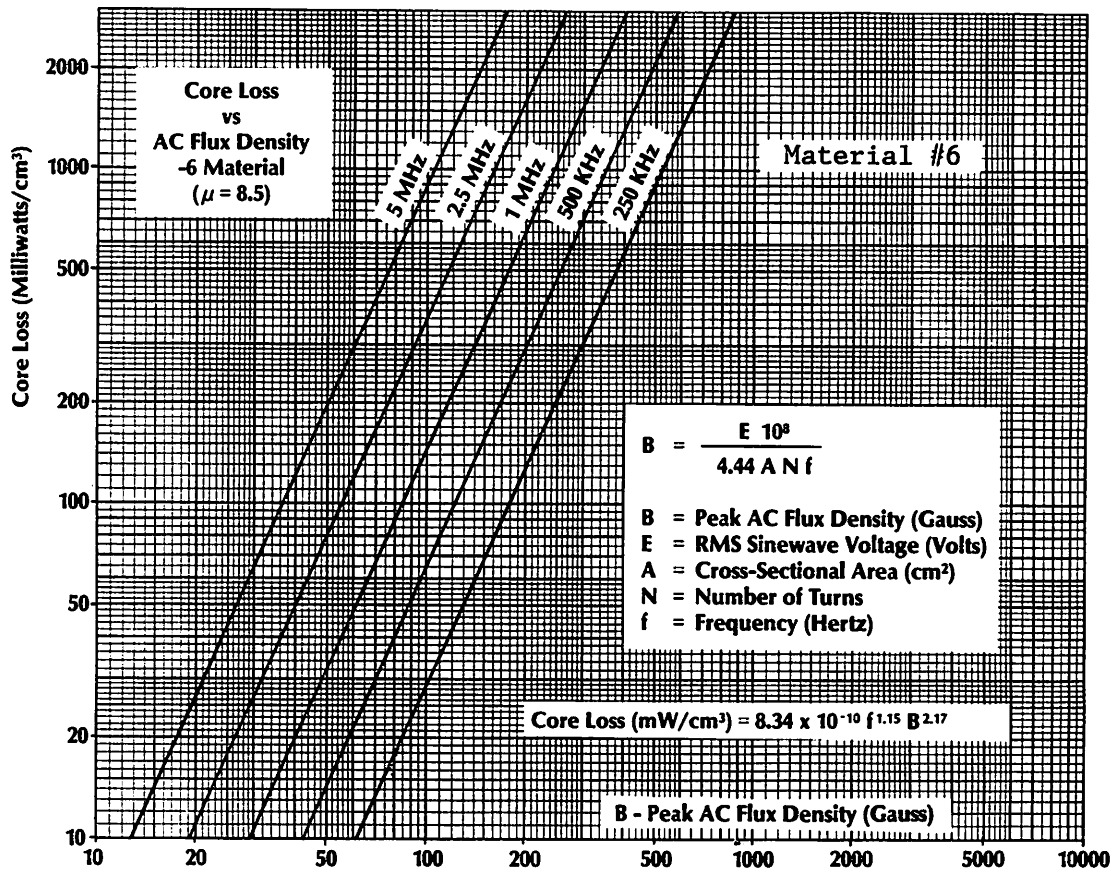
$$\text{Temp Rise (°C)} = \left[\frac{\text{Total Power Dissipation (Milliwatts)}}{\text{Surface Area (cm}^2\text{)}}\right]^{.833}$$

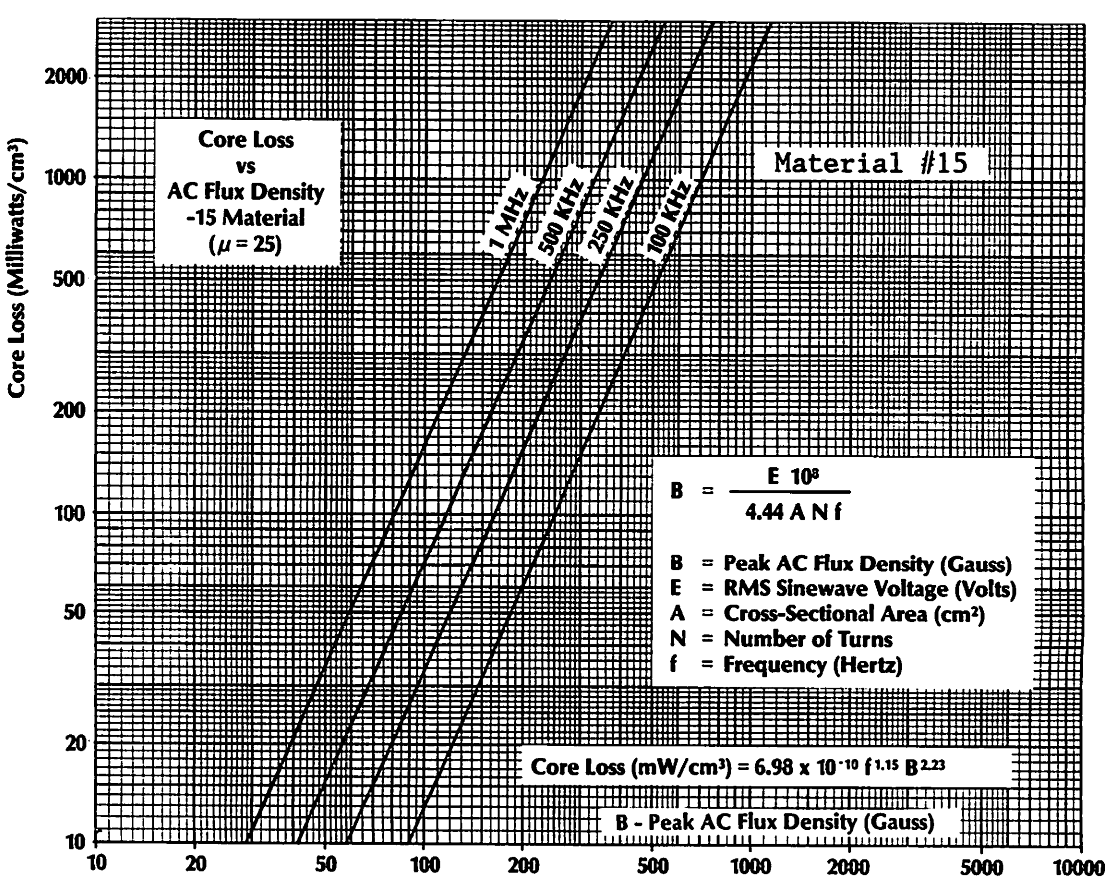
The surface area of a toroid increases at approximately a squared rate with the outside diameter, while the volume increases at approximately a cubed rate. The result is that a small diameter core can dissipate more power per unit volume than a larger diameter core for the same temperature rise.

Each of the three following graphs show core loss results in milliwatts per cubic centimeter as a function of frequency and AC flux density. These can be useful in projecting losses for frequencies not shown.

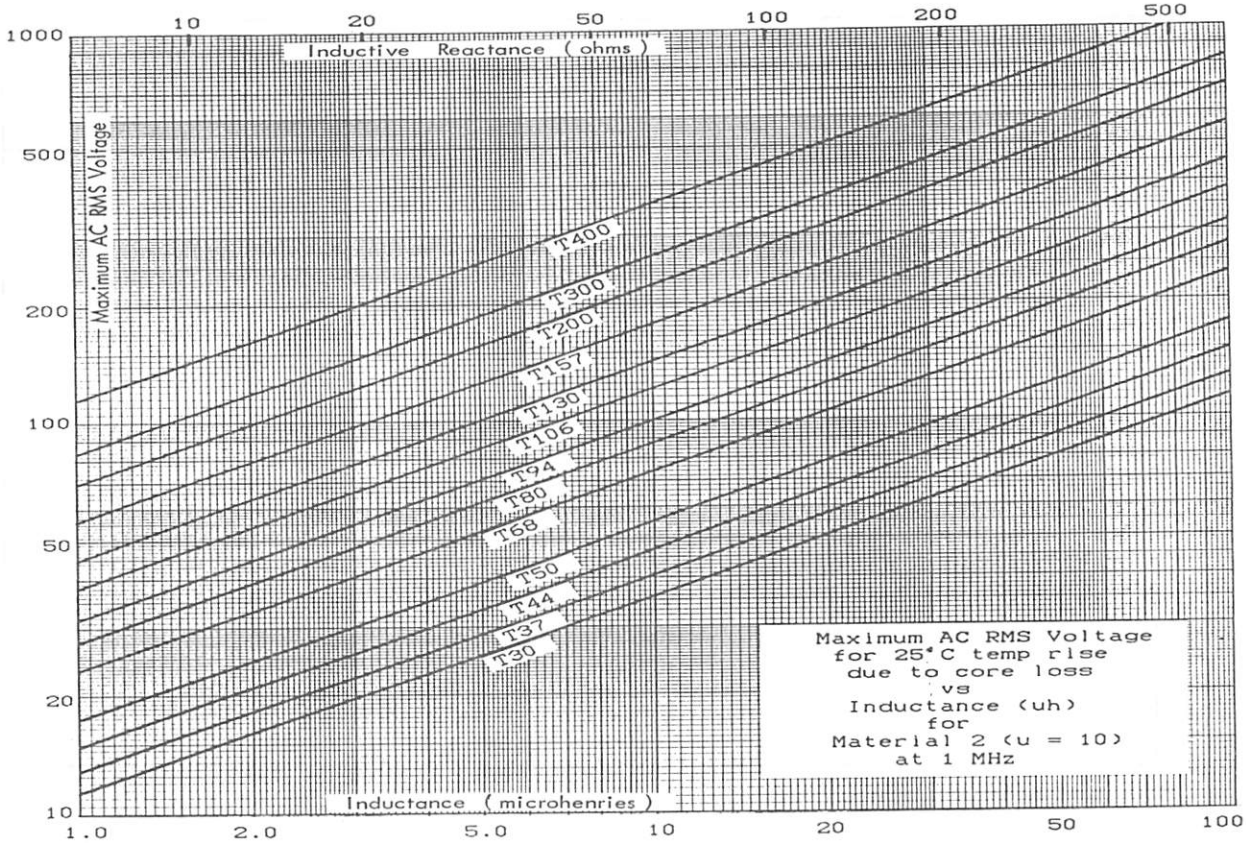


Iron Powder Core Loss Characteristics

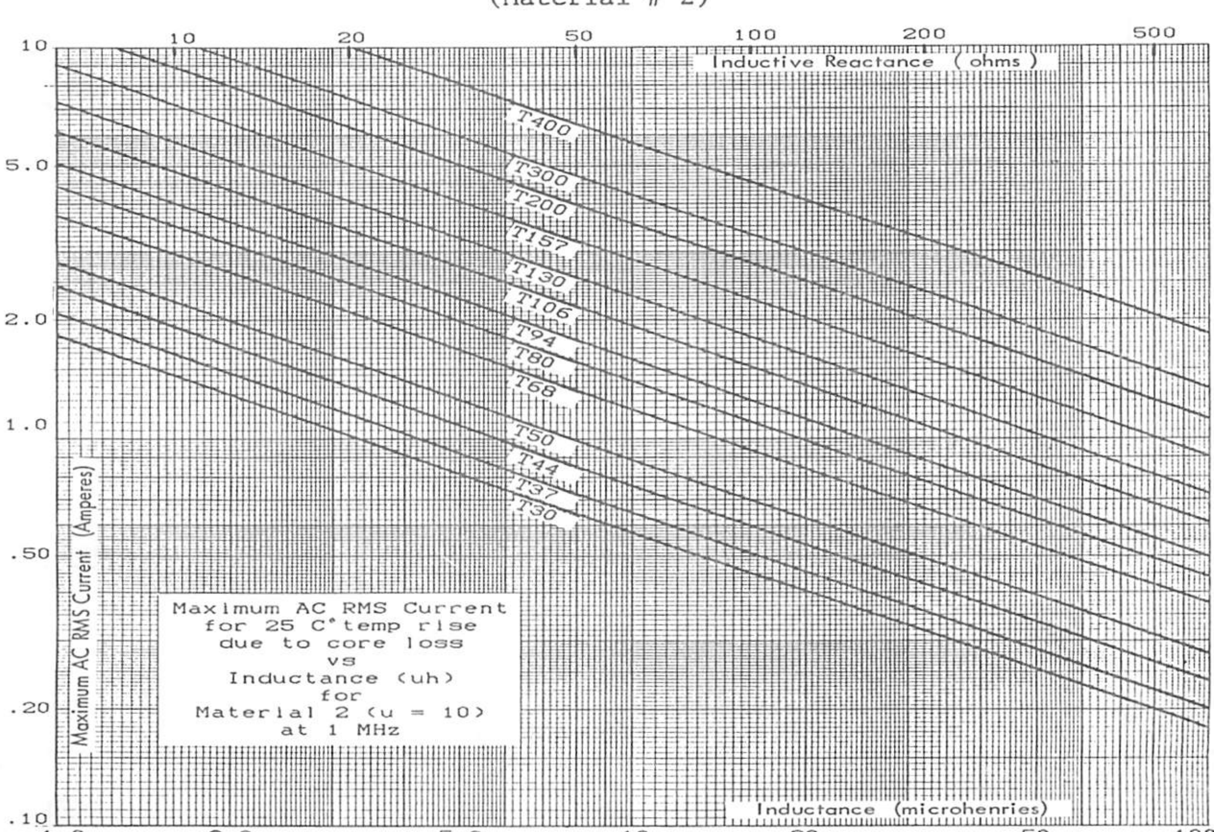




AC RMS VOLTAGE For 25°C Temperature Rise at 1 MHz.
(Material # 2)



AC RMS CURRENT For 25°C Temperature Rise at 1 MHz.
(Material # 2)

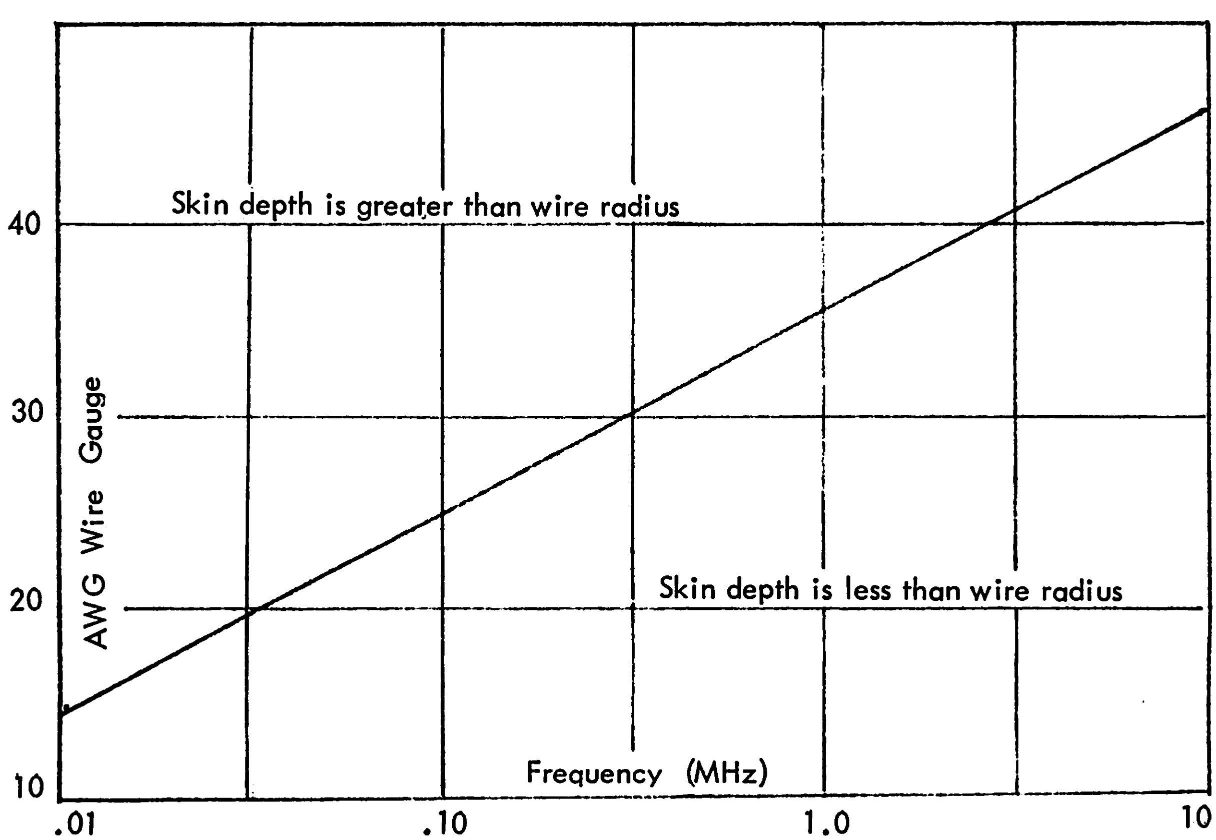


Power Dissipation vs. Temperature Rise

Power Dissipation (mw/cc) as a function of temperature rise			
Core Size	10°C	25°C	40°C
T- 30	400	1148	2026
T- 37	412	1170	2065
T- 44	310	884	1556
T- 50	307	874	1535
T- 68	234	664	1167
T- 80	212	602	1056
T- 94	160	454	802
T-106	114	322	566
T-130	117	331	582
T-157	94	266	468
T-200	87	260	436
T-300	62	186	327
T-400	43	130	228

Power rating for 25°C temp. rise due to core loss 2 Material, Freq. 1 MHz.	
Core Size	Watts
T- 30	24
T- 37	26
T- 44	37
T- 50	49
T- 68	88
T- 80	125
T- 94	160
T-106	236
T-130	331
T-157	515
T-200	794
T-300	1127
T-400	2108

Skin Effect vs. Frequency and Wire Size



Ferrite Cores

Ferrite Cores are available in numerous sizes and several permeabilities. Their permeability range is from 20 to more than 5000. They are very useful for resonant circuit applications as well as wideband transformers and they are also commonly used for RFI attenuation. We can supply sizes from .23 inches to 2.4 inches in outer diameter directly from stock.

Ferrite toroidal cores are well suited for a variety of RF circuit applications and their relatively high permeability factors make them especially useful for high inductance values with a minimum number of turns, resulting in smaller component size.

There are two basic ferrite material groups: those having a permeability range from 20 to 800 mu are of the NICKEL ZINC class and those having permeabilities above 800 mu are usually of the Manganese Zinc class.

NICKEL ZINC ferrite cores exhibit high volume resistivity, moderate stability and high 'Q' factors for the 500 KHz to 100 MHz frequency range. They are well suited for low power, high inductance resonant circuits and their permeability factors make them useful for wide band transformer applications.

The MANGANESE ZINC group of ferrites, having permeabilities from 800 mu to 5000 mu have fairly low volume resistivity and moderate saturation flux density. They can offer high 'Q' factors for the 1 KHz to 1 MHz frequency range. Cores from this group of materials are widely used for switched mode power conversion transformers operating in the 20 KHz to 100 KHz frequency range. These cores are also very useful for the attenuation of unwanted RF noise signals in the frequency range of 20 MHz. to 400 MHz and above.

A list of Ferrite toroids, including physical dimensions, magnetic properties, and the turns count formula for ferrite toroidal cores will be found on the next few pages. All items in this booklet are standard stock items and can usually be shipped immediately.

Ferrite Materials

MATERIAL 33 (u = 850) A manganese-zinc material having low volume resistivity. Used for low frequency antennas in the 1 KHz to 1 MHz. frequency range. Available in rod form only.

MATERIAL 43 (u = 850) High volume resistivity. For medium frequency inductors and wideband transformers up to 50 MHz. Optimum frequency attenuation from 40 MHz to 400 MHz. Available in toroidal cores. shield beads, balun cores and special shapes for RFI suppression.

MATERIAL 61 (u = 125) Offers moderate temperature stability and high 'Q' for frequencies 0.2 MHz to 15 MHz. Useful for wideband transformers to 200 MHz. and frequency attenuation above 200 MHz. Available in toroids, rods, bobbins and some two-hole baluns.

MATERIAL 63 (u = 40) For high 'Q' inductors in the 15 MHz to 25 MHz. frequency range. Available in toroidal form only.

MATERIAL 64 (u = 250) Primarily a bead material having high volume resistivity. Excellent temperature stability and very good shielding properties above 400 MHz.

MATERIAL 67 (u 40) Similar to the 63 material. Has greater saturation flux density and lower volume resistivity. Very good temperature stability. For high 'Q' inductors, (10 MHz to 80 Mhz.). Wideband transformers to 200 MHz. Toroids only.

MATERIAL 68 (u = 20) High volume resistivity and excellent temperature stability. For high Q' resonant circuits 80 MHz.to 180 MHz. For high frequency inductors. Toroids only.

MATERIAL 73 (u = 2500) Primarily a ferrite bead material, Has good attenuation properties from 1 MHz. through 50 MHz. Available in beads and some broadband balun cores.

MATERIAL 77 (u = 2000) Has high saturation flux density at high temperature. Low core loss in the 1 KHz to 1 MHz range. For low level power conversion and wideband transformers. Extensively used for frequency attenuation from 0.5 Mhz. to 50 MHz. Available in toroids, pot cores, E-cores, beads, broadband balun cores and sleeves. An upgrade of the former 72 material. The 72 material is still available in some sizes, but the 77 material should be used in all new design.

MATERIAL 'F' (u = 3000) High saturation flux density at high temperature. For power conversion transformers. Good frequency attenuation 0.5 MHz to 50 MHz. Toroids only.

MATERIAL 'J'/ 75 (perm 5000) Low volume resistivity & low core loss from 1 KHz.to 1 MHz. Used for pulse transformers and low level wideband transformers. Excellent frequency attenuation from 0.5 MHz to 20 MHz. Toroids and ferrite beads only.

FERRITE TOROIDAL CORES

MATERIAL 43 Permeability 850

Core number	O.D. (in)	I.D. (in)	Hgt (in)	ℓ_e cm	A_e cm^2	V_e cm^3	A_L value mh/1000 t
FT-23 -43	.230	.120	.060	1.34	.021	.029	188
FT-37 -43	.375	.187	.125	2.15	.076	.163	420
FT-50 -43	.500	.281	.188	3.02	.133	.401	523
FT-50A-43	.500	.312	.250	3.68	.152	.559	570
FT-50B-43	.500	.312	.500	3.18	.303	.964	1140
FT-82 -43	.825	.516	.250	5.26	.246	1.290	557
FT-114-43	1.142	.750	.295	7.42	.375	2.790	603
FT-140-43	1.400	.900	.500	9.02	.806	7.280	953
FT-240-43	2.400	1.40	.500	14.80	1.610	23.900	1239

MATERIAL 61 Permeability 125

Core number	O.D. (in)	I.D. (in)	Hgt (in)	ℓ_e cm	A_e cm^2	V_e cm^3	A_L value mh/1000 t
FT-23 -61	.230	.120	.060	1.34	.021	.029	24.8
FT-37 -61	.375	.187	.125	2.15	.076	.163	55.3
FT-50 -61	.500	.281	.188	3.02	.133	.401	68.8
FT-50A -61	.500	.312	.250	3.68	.152	.559	75.0
FT-50B -61	.500	.312	.500	3.18	.303	.964	150.0
FT-82 -61	.825	.516	.250	5.26	.246	1.290	73.3
FT-114 -61	1.142	.750	.295	7.42	.375	2.790	79.3
FT-114A-61	1.142	.750	.545	7.42	.690	5.130	146.0
FT-140 -61	1.400	.900	.500	9.02	.806	7.280	140.0
FT-240 -61	2.400	1.40	.500	14.80	1.610	23.900	171.0

MATERIAL 63/67 Permeability 40

Core number	O.D. (in)	I.D. (in)	Hgt (in)	ℓ_e cm	A_e cm^2	V_e cm^3	A_L value mh/1000 t
FT-23 -63/67	.230	.120	.060	1.34	.021	.029	7.9
FT-37 -63/67	.375	.187	.125	2.15	.076	.163	19.7
FT-50 -63/67	.500	.281	.188	3.02	.133	.401	22.0
FT-50A-63/67	.500	.312	.250	3.68	.152	.559	24.0
FT-50B-63/67	.500	.312	.500	3.18	.303	.964	48.0
FT-82 -63/67	.825	.516	.250	5.26	.246	1.290	22.4
FT-114-63/67	1.142	.750	.295	7.42	.375	2.790	25.4
FT-140- /67	1.400	.900	.500	9.02	.806	7.280	45.0
FT-240- /67	2.400	1.400	.500	14.80	1.610	23,900	50.0

MATERIAL 68 Permeability 20

Core number	O.D. (in)	I.D. (in)	Hgt (in)	ℓ_e cm	A_e cm^2	V_e cm^3	A_L value mh/1000 t
FT-23 -68	.230	.120	.060	1.34	.021	.029	4.0
FT-37 -68	.375	.187	.125	2.15	.076	.163	8.8
FT-50 -68	.500	.281	.188	3.02	.133	.401	11.0
FT-50A-68	.500	.312	.250	3.68	.152	.559	12.0
FT-82 -68	.825	.516	.250	5.26	.246	1.290	11.7
FT-114-68	1.142	.750	.295	7.42	.375	2.790	12.7

FERRITE TOROIDAL CORES

MATERIAL 77 (72)

Permeability 2000

Core\/number	O.D. (in)	I.D. (in)	Hgt (in)	ℓ_e cm	A_e cm^2	V_e cm^3	A_L value mh/1000 t
FT-23 -77	.230	.120	.060	1.34	.021	.029	396
FT-37 -77	.375	.187	.125	2.15	.076	.163	884
FT-50 -77	.500	.281	.188	3.02	.133	.401	1100
FT-50A -77	.500	.312	.250	3.68	.152	.559	1200
FT-50B -77	.500	.312	.500	3.18	.303	.964	2400
FT-82 -77	.825	.516	.250	5.26	.246	1.290	1170
FT-114 -77	1.142	.750	.295	7.42	.375	2.790	1270
FT-114A -77	1.142	.750	.545	7.42	.690	5.130	2340
FT-140 -77	1.400	.900	.500	9.02	.806	7.280	2250
FT-240 -77	2.400	1.400	.500	14.80	1.610	23.900	2740

MATERIAL 'F '

Permeability 3000

Core\/number	O.D. (in)	I.D. (in)	Hgt (in)	ℓ_e cm	A_e cm^2	V_e cm^3	A_L value mh/1000 t
FT-87A -F	.870	.540	.500	5.42	.522	2.830	3624
FT-114 -F	1.142	.748	.295	7.32	.369	2.701	1902
FT-150 -F	1.500	.750	.250	8.30	.581	4.822	2640
FT-150A-F	1.500	.750	.500	8.30	1.110	9.213	5020
FT-193 -F	1.932	1,252	.625	12.310	1.220	16.620	3640
FT-193A-F	1.932	1.252	.750	12.310	1.490	19.940	4460

MATERIAL 'J'(75)

Permeability 5000

Core\/number	O.D. (in)	I.D. (in)	Hgt (in)	ℓ_e cm	A_e cm^2	V_e cm^3	A_L value mh/1000 t
FT-23 -J	.230	.120	.060	1.34	.021	.029	980
FT-37 -J	.375	.187	.125	2.15	.076	.163	2196
FT-50 -J	.500	.281	.188	3.02	.133	.401	2715
FT-50A -J	.500	.312	.250	3.68	.152	.559	2968
FT-87 -J	.825	.516	.250	5.26	.246	1.290	3020
FT-87A -J	.870	.540	.312	5.42	.522	2.829	6040
FT-114 -J	1.142	.750	.295	7.42	.375	2.790	3170
FT-140 -J	1.400	.900	.500	9.02	.806	7.280	6736
FT-150 -J	1.500	.750	.250	8.30	.581	4.822	4400
FT-150A-J	1.500	.750	.500	8.30	1.110	9.213	8365
FT-193 -J	1.932	1.250	.525	12.31	1.220	16.620	6065
FT-240 -J	2.400	1.400	.500	14.80	1.610	23.900	6845

The following equations are useful for calculating the number of turns, the inductance or the A_L value of any Ferrite toroidal core. Each core has been assigned its own A_L value which is found in the preceding Ferrite toroidal core charts.

$$N = 1000\sqrt{\frac{\text{desired 'L' (mh)}}{A_L \text{ (mh/1000 turns)}}} \qquad L\text{ (mh)} = \frac{A_L \times N^2}{1{,}000{,}000} \qquad A_L\text{ (mh/1000 turns)} = \frac{1{,}000{,}000 \times \text{'L' (mh)}}{N^2}$$

N = number of turns

L = inductance (mh)

A_L = inductance index (mh / 1000 turns)

FERRITE TOROIDAL CORES

Physical Dimensions - Ferrite Toroids

core size \/	OD inches	ID inches	Hgt inches	Mean length cm	Cross Sect cm^2	Volume cm^3
FT-23	.230	.120	.060	1.34	.021	.028
FT-37	.375	.187	.125	2.15	.076	.163
FT-50	.500	.281	.188	3.02	.133	.402
FT-50 -A	.500	.312	.250	3.18	.152	.483
FT-50 -B	.500	.312	.500	3.18	.303	.963
FT-82	.825	.520	.250	5.26	.246	1.294
FT-87 -A	.870	.540	.500	5.42	.522	2.829
FT-114	1.142	.750	.295	7.42	.375	2.783
FT-114-A	1.142	.750	.545	7.42	.690	5.120
FT-140	1.400	.900	.500	9.02	.806	7.270
FT-150	1.500	.750	.250	8.30	.591	4.905
FT-150-A	1.500	.750	.500	8.30	1.110	9.213
FT-193	1.930	1.250	.625	12.30	1.190	14.637
FT-193-A	1.930	1.250	.750	12.31	1.460	17.958
FT-240	2.400	1.400	.500	14.40	1.570	22.608

A_L Values (mH / 1000 turns) - Ferrite Toroids

To complete the part number add the Mix number to the Core size number

The 63 & 72 materials are being superseded by the 67 & 77 materials respectively.

Material > / core size \/	43 u=850	61 u=125	63 u=250	67 u=40	68 u=20	72 u=2M	75 u=5M	77 u=2M	F u=3M	J u=5M
FT-23	188	24.8	7.9	7.8	4.0	396	990	356	NA	NA
FT-37	420	55.3	17.7	17.7	8.8	884	2210	796	NA	NA
FT-50	523	68.0	22.0	22.0	11.0	1100	2750	990	NA	NA
FT-50 -A	570	75.0	24.0	24.0	12.0	1200	2990	1080	NA	NA
FT-50 -B	1140	150.0	48.0	48.0	12.0	2400	NA	2160	NA	NA
FT-82	557	73.3	22.4	22.4	11.7	1170	3020	1060	NA	3020
FT-87 -A	NA	NA	NA	NA	NA	NA	NA	NA	3624	6040
FT-114	603	79.3	25.4	25.4	12.7	1270	3170	1140	1902	3170
FT-114-A	NA	146.0	NA	NA	NA	2340	NA	NA	NA	NA
FT-140	952	140.0	45.0	45.0	NA	2250	6736	2340	NA	6736
FT-150	NA	NA	NA	NA	NA	NA	NA	NA	2640	4400
FT-150-A	NA	N	NA	NA	NA	NA	NA	NA	5020	8370
FT-193	NA	NA	NA	NA	NA	NA	NA	NA	3640	6065
FT-193-A	NA	NA	NA	NA	NA	NA	NA	NA	4460	NA
FT-240	1240	173.0	53.0	53.0	NA	3130	6845	3130	NA	6845

Magnetic Properties - Ferrite Materials

Material >	43	61	63	67	68	72	75	77	F	J
Initial Perm.	850	125	40	40	20	2000	5000	2000	3000	5000
Max Perm.	3000	450	125	125	40	3500	8000	6000	4300	9500
Max Flux den. 14 oer, gauss	2750	2350	1850	3000	2000	3500	3900	4600	4700	4300
Residual flux density, gauss	1200	1200	750	1000	1000	1500	1250	1150	900	500
Vol. Resist. ohms/cm	$1x10^5$	$1x10^8$	$1x10^8$	$1x10^7$	$1x10^7$	$1x10^2$	$5x10^2$	$1x10^2$	$1x10^2$	$1x10^2$
Temp. Co-eff. 20-70 deg. C	1%	.15%	.10%	.13%	.06%	.60%	.90%	.60%	.25%	.4%
Curie Temp. C	130	350	450	500	450	150	160	200	250	140
Resonant Cir. Freq. MHz	.01 to 1 MHz	.2 to 10 MHz	15 to 25 MHz	10 to 80 MHz	80 to 180 MHz	.001- 1 MHz	.001- 1 MHz	.001- 1 MHz	.001- 1 MHz	.001- 1 MHz
Wideband Freq. MHz. *	1 to 50 MHz	10 to 200	25 to 200	50 to 500	200- 1000	.5 to 30 MH	.2 to 15 MHz	.5 to 30 MHz	.5 to 30 MHz	1 to 15 MHz
Attenuation RF Noise, MHz	20- 600	200- 1000	500- 2000	350- 1500	1000- 5000	1 - 50	.5- 20	1 - 50	1 - 50	.5 - 20

* Based on low power, small core applications: Listed frequencies will be lower with high power.

Inductance-Turns Chart, Ferrite Toroids

MATERIAL #43

turns count > core\/number	A_L*	10	20	30	40	50	60	70	80	90	100
				inductance in millihenries							
FT-23 -43	188	.018	.075	.169	.300	.470	.677	.921	1.20	1.52	1.88
FT-37 -43	420	.042	.168	.378	.672	1.05	1.51	2.06	2.69	3.40	4.20
FT-50 -43	523	.052	.209	.471	.836	1.30	1.88	2.56	3.35	4.24	5.23
FT-50A -43	570	.057	.228	.513	.912	1.43	2.05	2.79	3.65	4.62	5.70
FT-50B -43	1140	.110	.456	1.03	1.82	2.85	4.10	5.59	7.30	9.23	11.4
FT-82 -43	557	.056	.224	.503	.894	1.40	2.01	2.74	3.58	4.53	5.59
FT-114 -43	603	.060	.241	.543	.965	1.51	2.17	2.95	3.86	4.88	6.03
FT-140 -43	953	.095	.380	.857	1.52	2.38	3.43	4.66	6.09	7.71	9.52
FT-240 -43	1239	.123	.494	1.11	1.97	3.09	4.44	6.05	7.90	9.96	12.3

MATERIAL #61

turns count > core\/number	A_L*	10	20	30	40	50	60	70	80	90	100
				inductance in millihenries							
FT-23 -61	24.8	.002	.010	.022	.040	.063	.089	.122	.159	.201	.248
FT-37 -61	55.3	.006	.022	.050	.088	.138	.199	.271	.354	.448	.553
FT-50 -61	68.8	.007	.028	.062	.110	.172	.248	.337	.440	.557	.688
FT-50A -61	75.0	.008	.030	.068	.120	.186	.270	.366	.480	.608	.750
FT-50B -61	150.0	.015	.060	.135	.240	.375	.540	.735	.960	1.22	1.50
FT-82 -61	73.3	.007	.029	.066	.117	.183	.264	.359	.469	.594	.733
FT-114 -61	79.3	.008	.032	.071	.127	.198	.285	.389	.508	.642	.793
FT-114A-61	146.0	.015	.058	.131	.233	.365	.526	.715	.934	1.18	1.46
FT-140 -61	140.0	.014	.056	.126	.224	.350	.504	.686	.896	1.13	1.40
FT-240 -61	171.0	.017	.068	.154	.274	.428	.616	.838	1.09	1.39	1.71

MATERIAL #63/67

turns count > core\/number	A_L*	10	20	30	40	50	60	70	80	90	100
				inductance in millihenries							
FT-23 -63/67	7.9	----	.003	.007	.013	.020	.028	.038	.051	.064	.079
FT-37 -63/67	19.7	.002	.008	.018	.032	.049	.071	.097	.126	.160	.197
FT-50 -63/67	22.0	.002	.009	.020	.035	.055	.079	.108	.141	.178	.220
FT-50A-63/67	24.0	.002	.020	.033	.038	.060	.086	.112	.154	.194	.240
FT-50B-63/67	48.0	.005	.019	.043	.077	.120	.173	.235	.307	.389	.480
FT-82 -63/67	22.4	.002	.009	.020	.036	.056	.081	.110	.143	.181	.224
FT-114-63/67	25.4	.003	.010	.023	.041	.064	.091	.124	.163	.206	.254
FT-140-63/67	45.0	.005	.018	.041	.072	.118	.162	.220	.288	.365	.450
FT-240-63/67	53.0	.005	.021	.048	.084	.133	.199	.260	.339	.430	.530

MATERIAL #68

turns count > core\/number	A_L*	10	20	30	40	50	60	70	80	90	100
				inductance in millihenries							
FT-23 -68	4.0	----	.002	.004	.006	.010	.014	.020	.026	.032	.040
FT-37 -68	8.8	----	.006	.008	.014	.022	.032	.043	.056	.071	.088
FT-50 -68	11.0	.001	.004	.010	.018	.028	.040	.054	.070	.089	.110
FT-50A -68	12.0	.001	.005	.011	.019	.030	.043	.059	.077	.097	.117
FT-82 -68	11.7	.001	.005	.011	.019	.029	.042	.057	.075	.095	.117
FT-114 -68	12.7	.001	.005	.011	.020	.032	.046	.062	.081	.123	.127

Inductance-Turns Chart, Ferrite Toroids

MATERIAL #77

turns count > core\/number	A_L*	10	20	30	40	50	60	70	80	90	100
		inductance in millihenries									
FT-23 -77	396	.040	.158	.356	.634	.990	1.43	1.94	2.53	3.21	3.96
FT-37 -77	884	.088	.354	.796	1.41	2.21	3.18	4.33	5.66	7.16	8.84
FT-50 -77	1100	.110	.440	.990	1.76	2.75	3.96	6.39	7.04	8.91	11.0
FT-50A -77	1200	.120	.480	1.08	1.92	3.00	4.32	5.88	7.68	9.72	12.0
FT-50B -77	2400	.240	.960	2.16	3.84	6.00	8.64	11.7	15.4	19.4	24.0
FT-82 -77	1170	.117	.467	1.05	1.87	2.93	4.21	5.73	7.49	9.48	11.9
FT-114 -77	1270	.127	.508	1.14	2.03	3.18	4.57	6.22	8.13	10.3	12.7
FT-114A-77	2340	.234	.936	2.13	3.74	5.85	8.42	11.4	15.0	21.4	23,4
FT-140 -77	2250	.225	.900	2.03	3.60	5.63	8.10	11.3	14.4	18.2	22.5
FT-240 -77	2740	.274	1.10	2.47	4,38	6.85	9.86	13.4	17.5	22.2	27.4

MATERIAL F

turns count > Core\/number	A_L*	10	20	30	40	50	60	70	80	90	100
		inductance in millihenries									
FT-87A - F	3624	.362	1.45	3.26	5.80	9.06	13.0	17.8	23.2	29.4	36.2
FT-114 - F	1902	.190	.761	1.71	3.04	4.76	6.84	9.32	12.2	15.4	19.0
FT-150 - F	2640	.264	1.06	2.38	4.22	6.60	9.50	12.9	16.9	21.4	26.4
FT-150A- F	5020	.502	2.00	4.52	8.03	12.6	18.1	24.6	32.1	40.7	50.2
FT-193 - F	3640	.364	1.46	3.28	5.82	9.10	13.1	17.8	23.3	29.5	36.4
FT-193A- F	4460	.446	1.78	4.01	7.14	11.1	16.0	21.9	28.5	36.4	44.6

MATERIAL J/75

turns count > core\/number	A_L*	10	20	30	40	50	60	70	80	90	100
		inductance in millihenries									
FT-23 - J	980	.098	.394	.883	1.57	2.45	3.53	4.80	6.28	7.95	9.81
FT-37 - J	2196	.219	.878	1.98	3.51	5.49	7.90	10.8	14.1	17.8	21.9
FT-50 - J	2715	.278	1.89	2.44	4.34	6.74	8.77	13.3	17.3	22.0	27.1
FT-50A - J	2968	.296	1.19	2.69	4.75	7.42	10.7	14.5	19.0	24.0	29.6
FT-87 - J	3020	.302	1.21	2.72	4.83	7.55	10.9	14.8	19.3	24.5	30.2
FT-87A - J	6040	.604	2.42	5.44	9.66	12.6	21.7	29.6	38.7	48.9	60.4
FT-114 - J	3170	.317	1.27	2.85	5.07	7.93	11.4	15.5	20.3	25.7	31.7
FT-140 - J	6736	.674	2.69	6.06	10.8	16.8	24.2	33.0	43.1	54.6	67.4
FT-150 - J	4400	.440	1.76	3.96	7.04	11.0	15.8	21.6	28.1	35.6	44.0
FT-150A- J	8365	.837	3.35	7.53	13.4	20.9	30.1	41.0	53.5	67.8	83.7
FT-193 - J	6065	.607	2.43	5.46	9.70	15.2	21.8	29.7	38.8	49.1	60.7
FT-240 - J	6845	.684	2.34	6.16	11.8	17.1	24.6	33.5	43.8	55.4	68.4

* (A_L values in mh/1000 turns)

FERRITE BEADS

A Ferrite bead is a dowel-like device which has a center hole and is composed of ferromagnetic material. When placed on to a current carrying conductor it will act as an RF choke. It offers a convenient, inexpensive, yet a very effective means of RF shielding, parasitic suppression and RF decoupling.

The most common noise generating suspects in high frequency circuits are power supply leads, ground leads and connections, and interstage connections. Adjacent leads and unshielded conductors can also provide a convenient path for the transfer of energy from one circuit to another. A few ferrite beads of the appropriate material placed on these leads can greatly reduce or completely eliminate the problem. Best of all, they can be added to most any existing electronic circuit.

The amount of impedance is a function of both the material and the frequency, as well as the size of the bead. As the frequency increases, the permeability will decline causing the losses to rise to a peak. With a rise in frequency the bead will present a series resistance with very little reactance. Since reactance is low there is little chance of resonance which could destroy the attenuation effect. Impedance is directly proportional to the length of the bead, therefore impedance will be additive as each similar bead is slipped onto the conductor. Since the magnetic field is totally contained within, it does not matter if the beads are touching or separated. Ferrite beads do not have to be grounded and they cannot be detuned by external magnetic fields.

We recommend the #73 or the #77 ferrite bead material for the attenuation of RFI resulting from transmissions in the amateur band. The #43 material will provide best RFI attenuation from 30 to 400 MHz, and the #64 material is most effective above 400 MHz. The #75 material is recommended for RFI from 1 to 20 MHz, but they can also be quite effective even below the AM broadcast band.

Ferrite beads are usually quite small and as a result only one pass, or a small number of turns are possible. On the other hand, a toroidal core usually has a much larger ID and will accept a greater number of turns. The greater number of turns can be an advantage in some cases where a large amount of impedance is required, since the impedance increases as to the number of turns squared.

The number of turns on a single hole Ferrite bead or a toroidal core is identified by the number of times the conductor passes through the center hole. To physically complete one turn it would be necessary to cause the wires to meet on the outside of the device, however the bead or core does not care about the termination of each end of the wire and considers each pass through the center hole as one turn. (This does not apply to multihole beads)

When winding a six-hole bead, the impedance depends upon the exact winding pattern. For instance, it can be wound clock-wise or counter clock-wise progressively from hole to hole, or criss-crossed from side to side, or each turn can be completed around the outside of the bead. Each type of winding will produce very different results. The impedance figures for the six-hole bead in our chart is based on the current industry standard, which is two and one half turns threaded through the holes, criss-crossing from one side to the other.

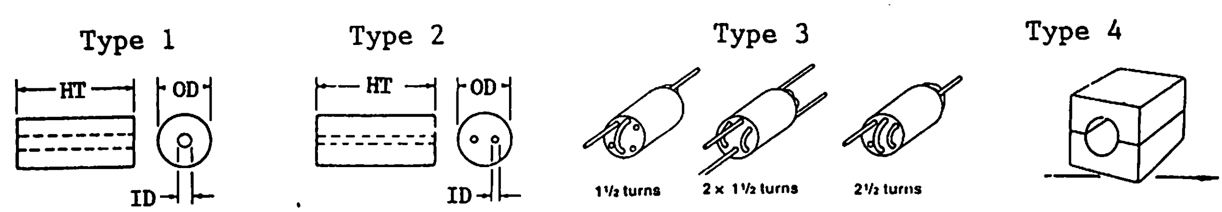
Temperature rise above the Curie point will cause the bead to become non-magnetic, rendering it useless as a noise attenuating device. Depending on the material, Curie temperature can run anywhere from 120°C to 500°C . See 'Magnetic Properties' chart for specifics.

The #73 and #75 materials, as well as other very high permeability materials are semi-conductive and care should be taken not to position the cores or beads in such a manner that they would be able to short uninsulated leads together, or to ground. Other lower permeability materials with higher resistivity are non-conductive and this precaution is not necessary.

Ferrite Shielding Beads

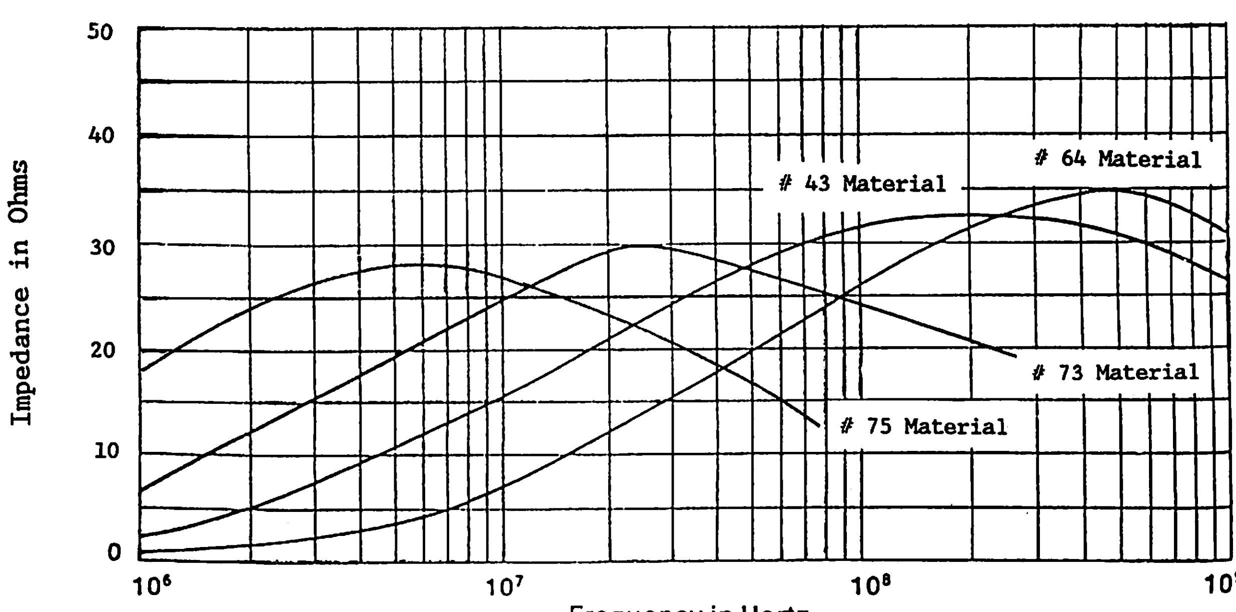
Part number	Bead type	OD	ID	Hgt	43	64	73	75	77	Impedance factor*
		Dimensions (inches)			A_L of Materials (mh/1000 t)					
FB-(--)-101	1	.138	.051	.128	510	150	1500	3000	----	1.0
FB-(--)-201	1	.076	.043	.150	360	110	1100	----	----	0.7
FB-(--)-301	1	.138	.051	.236	1020	300	3000	----	----	2.0
FB-(--)-801	1	.296	.094	.297	1300	390	3900	----	----	2.5
FB-(64}-901	2	.250	.050	.417	----	1130	----	----	----	* *
FB-(--)-1801	1	.200	.062	.437	2000	590	5900	----	----	3,9
FB-(--)-2401	1	.380	.197	.190	520	----	1530	----	----	1.1
FB-(--)-5111	3	.236	.032	.394	3540	1010	----	----	----	***
FB-(--)-5621	1	.562	.250	1.125	3800	----	----	----	9600	7.4
FB-(--)-6301	1	.375	.194	.410	1100	----	----	----	2600	2.1
FB-(43)-1020	1	1.000	.500	1.112	3200	----	----	----	----	6.2
FB-(77)-1024	1	1.000	.500	.825	----	----	----	----	5600	3.7
2X-(43)-151	4	1.020	.500	1.125	Split bead type,			material 43 only.		
2X-(43)-251	4	.590	.250	1.125	Split bead type,			material 43 only.		

Notes: Complete the part number by adding material number in (--) space provided.
A_L values based on low frequency measurements. (mh/1000 turns) equal to nanohenries/turns^2
** Based on a single 'U-turn' winding. *** Based on a 2 1/2 turn, side to side winding.



Material vs Frequency vs Impedance

* Impedance Factor: The following chart is based on the '101' size bead which will be used as a reference. Impedance in ohms for a given size bead can be approimated, if the impedance of the '101' size bead (from the curves) is multiplied by the impedance factor for the given bead.



Ferrites for RFI

Ferrite toroidal cores, as well as beads, can be very useful in attenuation of unwanted RF signals but we do not claim them to be a cure-all for all RFI problems. There are different types of noise sources, each of which may require a different approach. When dealing with any noise problem it is helpful to know the frequency of the interference. This is valuable when trying to determine the correct material as well as the maximum turns count.

RFI emanating from such sources as computers, flashing signs, switching devices, diathermy machines, etc. are very rich in harmonics and can create noise in the high and very high frequency regions. For this type of interference, the #43 material is probably the best choice since it has very good attenuation in the 20 MHz to 400 MHz. region. Some noise problems may require additional filtering with hi-pass or lo-pass filters. If the noise is of the differential-mode type, an AC line filter may be required. See section on AC line filters and DC chokes.

In some cases the selected core will allow only one pass of the conductor, which is considered to be one turn. In other cases it may be possible to wind several turns on to the core. When installing additional cores on the same conductor, impedance will be additive. When multiple turns are passed through a core, the impedance will increase in relation to the number of turns squared.

Keep in mind that because of the wide overlap in frequency range of the various materials, more than one material can provide acceptable results. Normally, the 43 material is recommended for frequency attenuation above 30 MHz., the 77, and 'F' materials for the amateur band, and the 'J' or materials for everything lower than the amateur band.

Computers are notorious for RF radiation, especially some of the older models which were made when RFI requirements were quite minimal. RFI can radiate from inter-connecting cables, AC power cords and even from the cabinet itself. ALL of these sources must be eliminated before complete satisfaction can be achieved. First, examine the computer cabinet to make sure that good shielding and grounding practices have been followed. If not, do what you can to correct it. If you suspect that RF is feeding back into the AC power system from your computer, wrap the power cord through an FT-240-77 toroidal core 6 to 9 times. This will act as an RF choke on the power cord and should prevent RF from feeding back into the power system where it can affect other electronic devices.

It is possible for an unwanted RF signal to enter a piece of equipment by more than one path, If so, ALL of these paths must be blocked before there will be noticeable effect. Don't overlook the fact that RFI may be entering the equipment by radiation directly from your antenna feed line due to high SWR. This, of course, can be checked with an SWR meter, and can be corrected by installing an antenna balun, or by placing a few ferrite beads, or sleeves, over the transmission line at the antenna feed point. This should prevent RF reflection back into the outside shield of the coax feed line, which could radiate RFI.

Split bars are especially designed for computer flat ribbon cables. Two or more cores can be placed on the same cable, in which case the impedance will be additive. See following page for more specific information.

RFI in telephones can be substantially reduced with the insertion of an RF choke in each side of the talk circuit. Wind two FT-50A-75 cores with about 20 turns each of #26 enamelled wire. If possible, place one in each side of the talk circuit within the telephone base. If this is not possible, try mounting them in a small box with phone modular input and output jacks mounted in each end. This can now be used 'in-line' between the phone and the wall jack. Similar results can be achieved by winding 6 to 9 turns of the telephone-to-wall cable through an FT-140-J ferrite toroidal core.

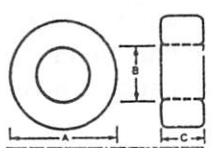
FERRITE CORES FOR RFI SUPPRESSION

Following is a list of ferrite Beads (FB), ferrite Toroidal Cores (FT), and split ferrite Cores (2X), all of which are extensively used for RFI problems involving multiple wire bundles, coaxial cables, microphone cables, AC cords, and computer ribbon cables.

The 43 material is a good all around material for most RFI problems. However the lower frequencies from 0.5 MHz to 10 MHz. can best be served with the 'J' or 75 material. The 77 material can provide excellent attenuation of RFI caused by amateur radio frequencies from 2 MHz to 30 MHz. and the 43 material is best for everything above 30 MHz. See previous page for more information.

Split cores (identified by prefix 2X) are now available and can be installed without removing the end connector from the cable. Split bars are also now available and especially designed for computer ribbon cables. At present they are available for 1.3", 2.0" and 2.5" computer ribbon cables. Two or more may be used on the same ribbon cable to increase the impedance.

Shown below are typical impedances in ohms at 25 and 100 MHz with only one pass through the core.

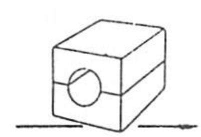


Part number	A dim. (in)	B dim. (in)	C dim. (in)	25 MHz	100 MHz
FT-50B-43	.500	.312	.500	56	90
FT-50B-77	.500	.312	.500	74	60
FT-114-43	1.142	.750	.295	27	47
FT-114-77	1.142	.750	.295	35	29
FT-140-43	1.400	.900	.500	47	75
FT-140-77	1.400	.900	.500	62	50
FT-193- J	1.930	1.250	.625	below 10 MHz	
FT-240-43	2.400	1.400	.500	58	108
FT-240-77	2.400	1.400	.500	76	66

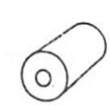
Two turns

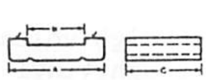
Note: All of the above size cores are available in the 'J' material which will be most effective if the troublesome frequency is below 10 MHz. Other cores can be used for RFI, not mentioned here

Part number	A dim. (in)	B dim. (in)	C dim. (in)	25 MHz	100 MHz
2X-43-251	.590	.250	1.125.	171	275
2X-43-151	1.020	.500	1.125	159	245

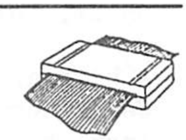


Part number	A dim. (in)	B dim. (in)	C dim. (in)	25 MHz	100 MHz
FB-43-1020	1.000	.500	1.120	155	235
FB-77-1024	1.000	.500	.825	166	135
FB-43-5621	.562	.250	1.125	171	250
FB-77-5621	.562	.250	1.125	270	215
FB-43-6301	.275	.194	.410	55	48
FB-77-6301	.275	.194	.410	73	59





Part number	Description	25 MHz	100 MHz
2X-43-651	for 1.3" ribbon cable	97	200
2X-43-951	for 2.0" ribbon cable	105	285
2X-43-051	for 2.5" ribbon cable	90	250



Broadband Transformers

Broadband Transformers, as the name implies, are transformers which will operate over a broad frequency range. They can also provide a step-up or a step-down impedance transformation, match an unbalanced source to a balanced load, or serve both purposes

The two-hole, or 'binocular' type, ferrite core, known as the balun core, is very popular for low power applications. Balun cores were developed to provide maximum impedance per length of turn in order to better serve the broadband transformer. Two-hole balun cores are widely used as 75 ohm and 300 ohm matching transformers for receivers and low power UHF and VHF applications.

The bandwidth of a broadband transformer has practical limitations. The functions which control the low frequency performance are parallel inductance and parallel resistance. This combination must remain sufficiently high in order to maintain an acceptable match. Unless a very low 'Q' core is used these will be the dominant factors. Normally, the inductive reactance at the lowest frequency should be four times greater than the source impedance. However, in order to achieve this ratio, we may find that excessive turns may be required which will adversely affect the high frequency performance. Using a core of high permeability will minimize the number of required turns.

The factors which limit the high frequency response are distributed capacity and inductance leakage due to uncoupled flux. The more the distributed capacity and the flux leakage can be minimized, the better will be the high frequency performance of the transformer. The best compromise between distributed capacity and leakage inductance can be obtained by twisting the conductors together prior to winding. This greatly minimizes the leakage inductance in small transformers.

In applications which generate minimal flux, such as in low power applications and one to one ratio transformers, the goals can best be accomplished by using a high permeability core in order to minimize turns at the lowest frequency. This in turn, will minimize the distributed capacity which will improve the high frequency response.

Generally, ferrite cores are preferred for broadband transformers because of their high permeability factors. However, in power applications the high permeability ferrite cores can be easily saturated, and care must be taken to keep the induced flux density well below the maximum flux density rating of the core in order to confine the signal energy to the linear portion of the flux density curve. Detailed information can be found in the 'Ferromagnetic Design and Applications Handbook' by Doug DeMaw. We now stock this item.

The main concern in power applications is core loss generated by the net induced flux. In this case, iron powder cores are generally preferred because of their higher maximum flux density rating. Core loss increases at a squared rate with flux density at any given frequency. When extremely high voltages are encountered, such as in a high impedance ratio step-up transformer, we recommend that the core first be wrapped with glass-electrical tape before winding, such as 3M-27, This will provide added protection against voltage breakdown and arcing.

A high grade of wire insulation is required when operating with high voltages. We recommend 'Thermoleze' insulated wire. This is a very tough vinyl-like insulation having a voltage breakdown potential of better than 2000 volts and a temperature rating of 200°C.

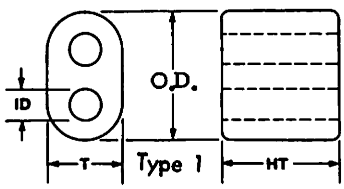
BALUN and WIDEBAND CORES

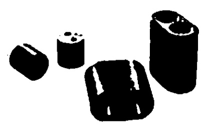
The two-hole balun is commonly used for winding high frequency wideband transformers. These transformers may be used for impedance transformation, to provide isolation, or both.

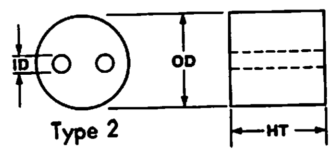
The primary concern when designing a wideband transformer is to extend the bandwidth with minimum loss. The factors which limit the bandwidth are inductive reactance and core loss which will limit operation at the lower frequencies, also leakage inductance and distributed capacitance which will limit operation at the higher frequencies.

The two-hole balun may be wound through both holes or through one hole and around the outside. Winding through both holes will produce a higher inductance per turn. Ferrite toroids and ferrite beads may also be used for winding wideband transformers, however these configurations will produce narrower bandwidth than the two-hole balun core.

For wideband application, the #73 material is suitable up to 30 MHz. The #43 material is most often used for frequencies from 20 to 50 or 60 MHz. For frequencies above this point use the #61 material.







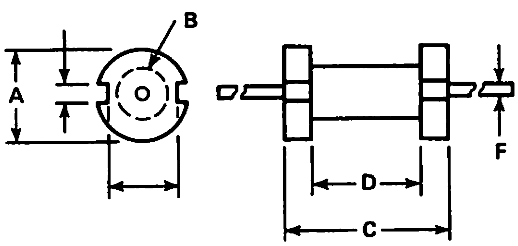
Dimensions in inches A_L values in mh/1000 turns

	O.D	I.D	Hgt.	Th	type	A_L
BN-43-202	.525	.150	.550	.295	1	2890
BN-43-2302	.136	.035	.240	.080	1	680
BN-43-2402	.280	.070	.240	.160	1	1275
BN-43-3312	.765	.187	1.000	.375	1	5400
BN-43-7051	1.130	.250	1.130	.560	1	6000
BN-61-202	.525	.150	.550	.295	1	425

	O.D	I.D	Hgt	Th	type	A_L
BN-61-2302	.136	.035	.240	.080	1	100
BN-61-2402	.280	.070	.240	.160	1	150
BN-61-1702	.250	.050	.470	--	2	420
BN-61-1802	.250	.050	.240	--	2	310
BN-73-202	.525	.150	.550	.295	1	8500
BN-73-2402	.275	.070	.240	.160	1	3750

Ferrite Bobbin Cores

Ferrite bobbins provide a convenient means of winding RF chokes. Because of their open magnetic path, they can handle more current than toroids of similar size. To aid in the design of such chokes, we have provided A_L values, a winding table, and ampere-turn ratings for each bobbin.



Winding table: number of turns to completely fill bobbin.

wire size	20	22	24	26	28	30	32	34	36
B-72-1111	9	14	23	35	56	88	164	205	400

wire size	20	22	24	26	28	30	32	34	36
B-72-1011	24	39	60	93	148	230	425	535	1050

B O B B I N   D I M E N S I O N S A_L value in mh/1000 turns

part number	A	B	C	D	F	A_L	NI
Bobbin # B-72-1111	.196"	.107"	.500"	.400"	#22	17	60
Bobbin # B-72-1011	.372"	.187"	.750"	.500"	#20	39	130

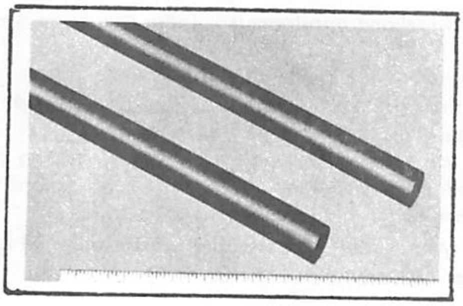
BOBBIN # B-72-1111 A_L= 17   NI= 60

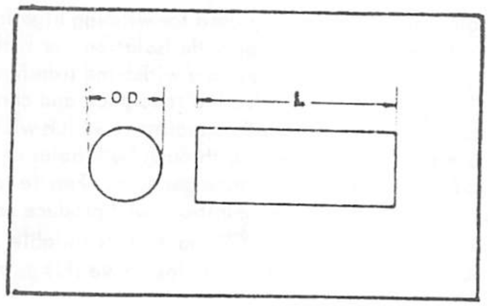
Inductance	wire turns	wire size	I (max)
10 uh	24	24	2.50
25 uh	38	26	1.60
50 uh	54	28	1.10
100 uh	77	30	.78
250 uh	121	31	.50
500 uh	171	32	.35
1.0 mh	243	34	.25
2,5 mh	383	36	.16
5.0 mh	542	37	.11
10.0 mh	762	38	.08

BOBBIN # B-72-1011 A_L=39   NI = 130

Inductance	wire turns	wire size	I (max)
25 uh	25	20	5.20
50 uh	36	22	3.60
100 uh	50	24	2.60
250 uh	80	26	1.60
500 uh	113	27	1.10
1.0 mh	160	28	.80
2.5 mh	253	30	.50
5.0 mh	358	32	.36
10.0 mh	506	34	.25
25.0 mh	800	36	.16

Ferrite Rods





Part number	Material	Perme-ability	Diameter (in)	Length (in)	Al value mh/1000 t	Ampere turns
R61-025-400	61	125	.25	4.0	26	110
R61-033-400	61	125	.50	4.0	32	185
R61-050-400	61	125	.50	4.0	43	575
R61-050-750	61	125	.50	7.5	49	260
R33-037-400	33	800	.37	4.0	62	290
R33-050-200	33	800	.50	2.0	51	465
R33-050-400	33	800	.50	4.0	59	300
R33-050-750	33	800	.50	7.5	70	200

FERRITE RODS are available in various sizes of both the #33 and #61 materials, which are standard stock items here at Amidon. The most common use of a ferrite rods is for antennas and choke applications.

ANTENNAS: The #61 material rods are widely used for commercial AM radio antennas and on up to 10 MHz. The #33 material rods are more suitable for the VLF frequency range.

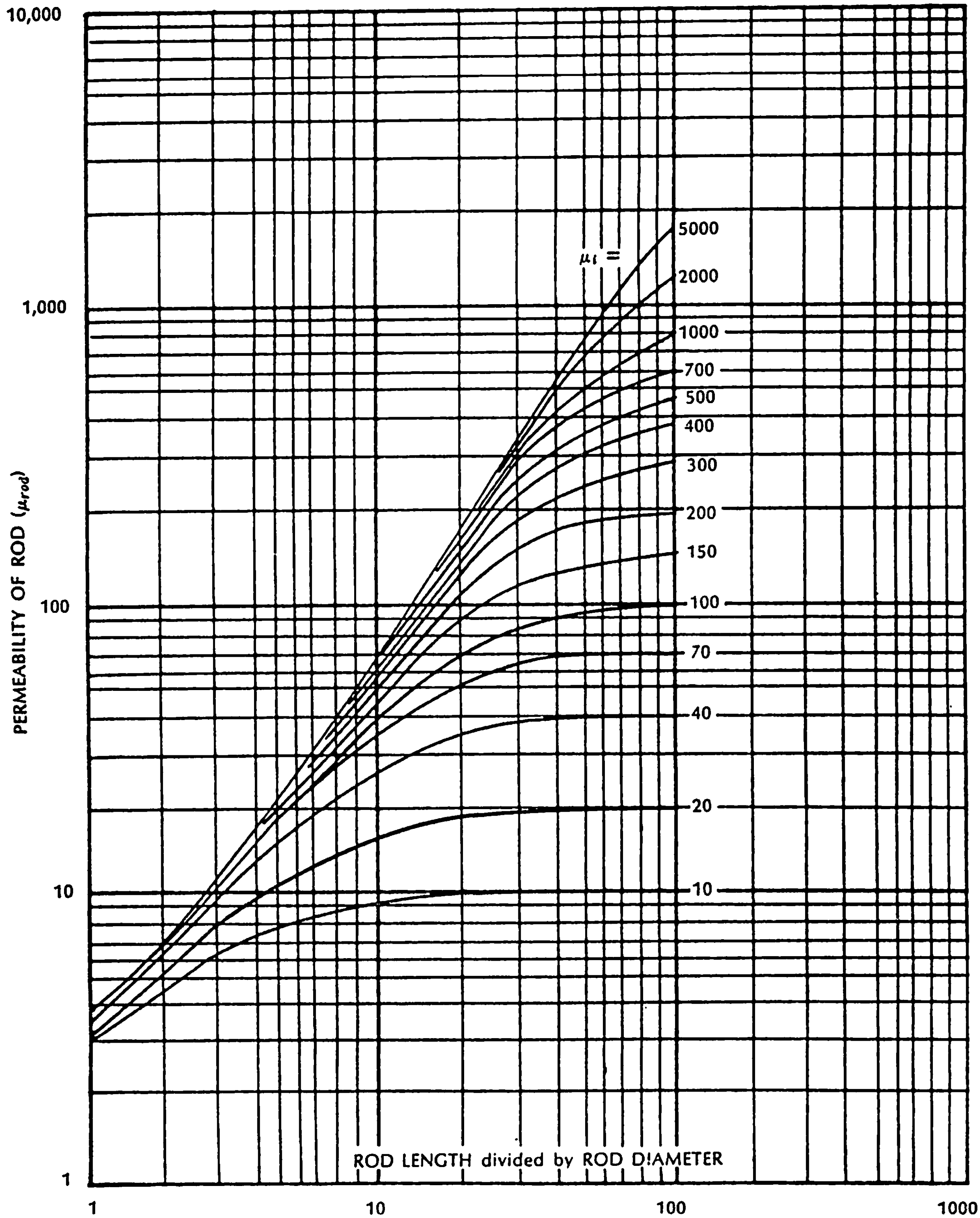
CHOKE APPLICATIONS; Both the #33 and the #61 material rods are extensively used in choke applications. The #33 material should be selected for the 40 and 80 meter bands and the #61 material is most suitable for 10 through 40 meters. The #33 material rods are also often used in speaker cross-over networks. Due to the open magnetic structure of the rod configuration, considerable current can be tolerated before it will saturate.

There are several factors that have a direct bearing on the effective permeability of a ferrite rod, which in turn will effect inductance and 'Q', as well as the A_L value of the rod and its ampere-turns rating. These are: (1) Length to diameter ratio of the rod, (2) Placement of the coil on the rod , (3) Spacing between turns and, (4) Air space between the coil and the rod. In some cases the effective permeability of the rod will be influenced more by a change in the length to diameter ratio than by a change in the initial permeability of the rod. At other times, just the reverse will be true.

Greatest inductance and A_L value will be obtained when the winding is centered on the rod, rather than placed at either end. The best 'Q' will be obtained when the winding covers the entire length of the rod.

Because of all of the above various conditions it is very difficult to provide workable A_L values, however we have attempted to provide a set of A_L and NI values for various types of rods in our stock. These figures are based on a closely wound coil of #22 wire, placed in the center of the rod and covering nearly the entire length. Keep in mind that there are many variables and that the inductance will vary according to winding technique.

Permeability of Ferrite Rods



PERMEABILITY OF ROD vs. ROD LENGTH DIVIDED BY ROD DIAMETER FOR VARIOUS MATERIAL PERMEABILITIES

This family of curves shows the value of the effective permeability of a ferrite rod as a function of its length to diameter ratio, as well as a function of the material permeability of the rod. It illustrates that generally, a great difference exists between the material permeability and the effective permeability of a rod. It also illustrates how, in some instances, the effective permeability of a rod can be influenced by changing its mechanical dimensions, more than by changing its material permeability, while in other cases, the reverse is true.

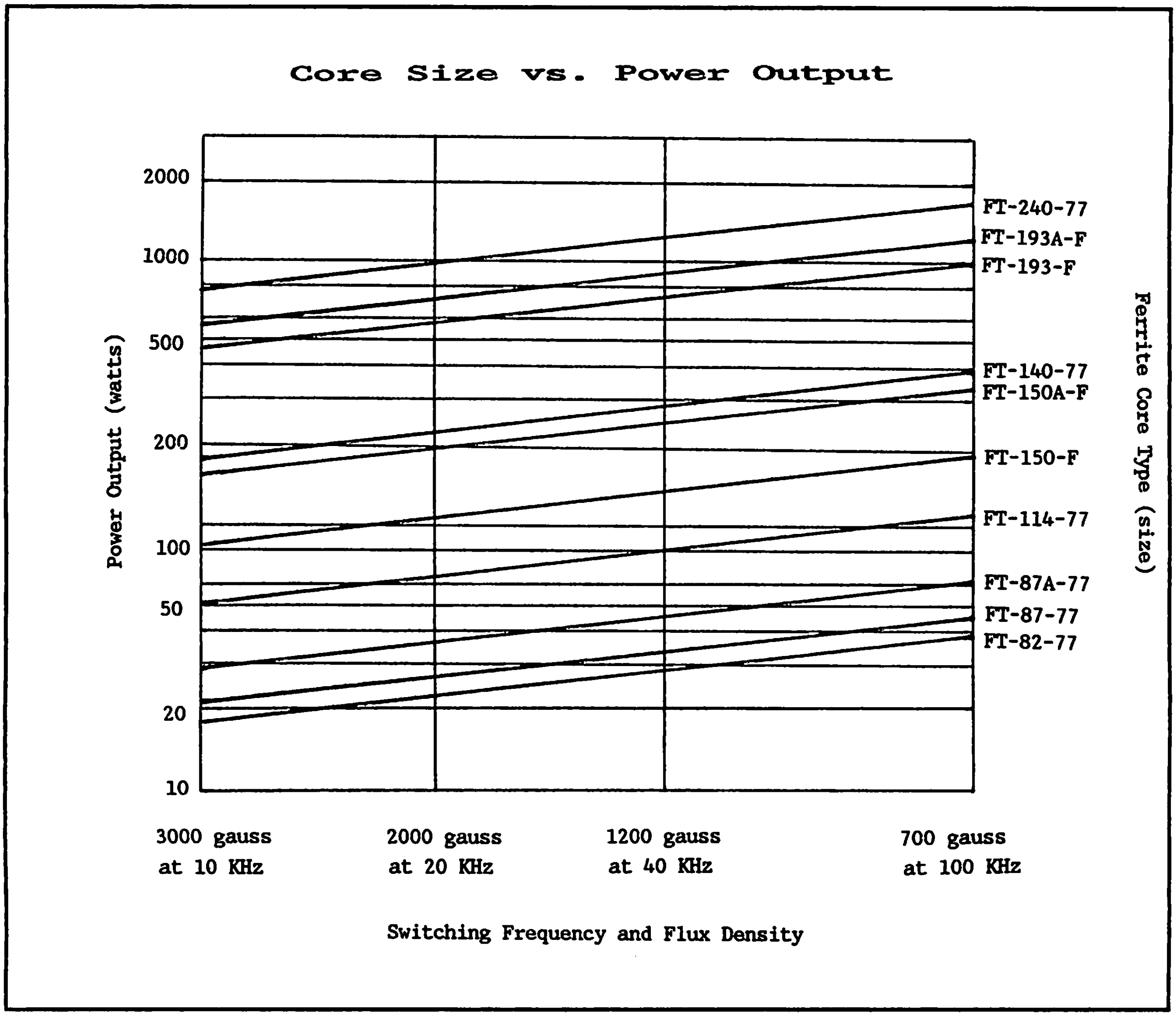
Switched Mode Power Supplies

Guide to select the proper size ferrite core

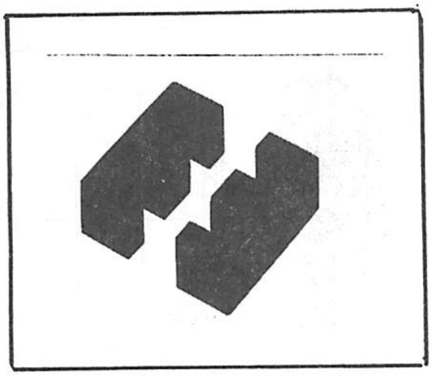
Switching power supplies require the use of high permeability Ferrite type cores, rather than high permeability Iron Powder cores. High permeability Iron Powder cores will be to lossy.

Toroidal cores may be used, however 'E' type cores are generally preferred because of greater winding ease. We stock both the Toroidal Ferrite cores and the 'E' cores in the #77 material, which is ideal for switching at frequencies of 20 KHz or higher.

See other pages in this brochure on 'E' cores for size vs. power. The chart at the bottom of this page will provide data on an approximate size toroidal core to be used for a given amount of power.

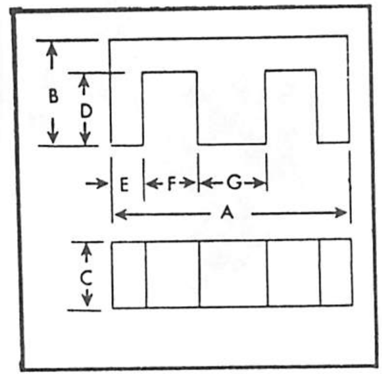


FERRITE 'E' CORES



TYPE 77 FERRITE MATERIAL
permeability 2000

These cores are ideally suited for low power applications up to 200 watts. A nylon bobbin is supplied for easy winding.



E-Core Physical Dimensions (inches)

Part No. \/	A	B	C	D	E	F	G	Power
EA-77-188	.760	.318	.187	.225	.093	.192	.187	10 watts
EA-77-250	1.000	.380	.250	.255	.125	.250	.250	20 watts
EA-77-375	1.375	.562	.375	.375	.187	.312	.375	70 watts
EA-77-500	1.625	.650	.500	.405	.250	.312	.500	100 watts
EA-77-625	1.680	.825	.605	.593	.234	.375	.468	200 watts

E-Core Magnetic Properties

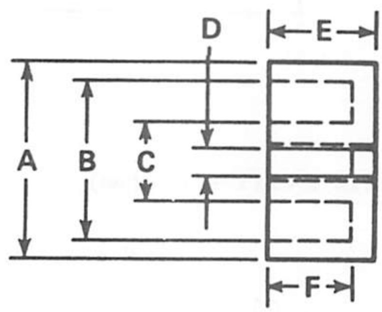
Part No. \/	A_e mm^2	I_e mm	Ve mm^3	A_s mm^2	A_w mm^2	$A_c \times A_w$ mm^4	A_L value mh/1000 turns
E-77-188	22.5	40.1	900	1050	55.7	1250	1060
E-77-250	40.4	48.0	1930	1700	80.6	3250	1660
E-77-375	90.3	68.8	6240	3630	151.0	13700	2760
E-77-500	160.0	76.7	12300	5410	163.0	26100	4470
E-77-625	184.0	98.0	18000	7550	287.0	52900	4150

Wire size vs. Number of turns

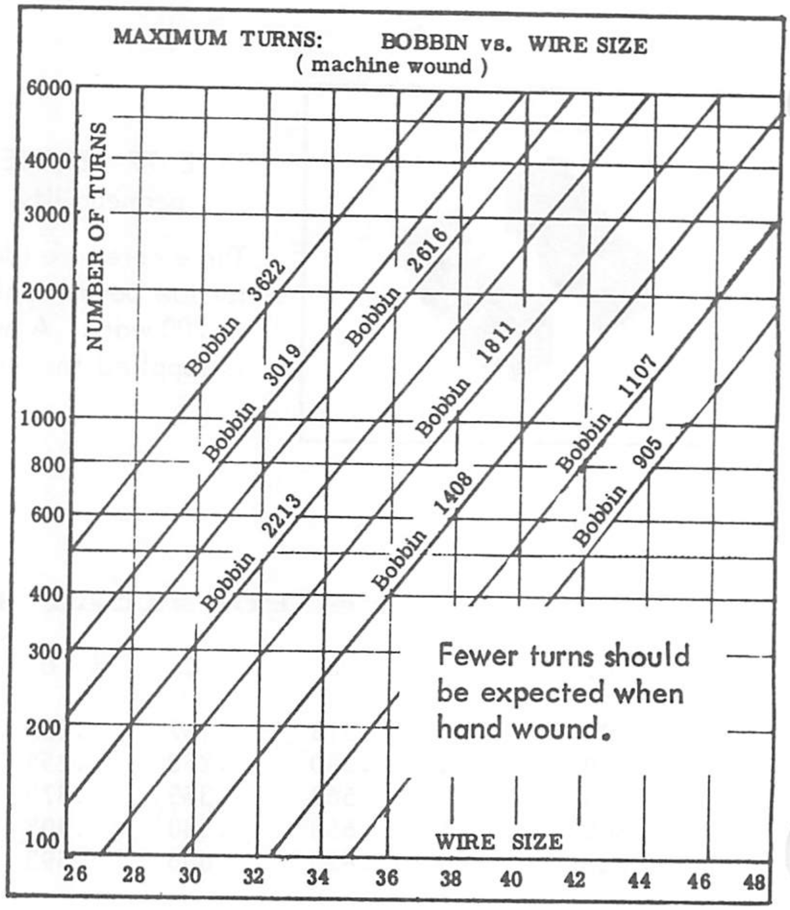
Part No. \/	18	20	22	24	26	28	30	32	34	36	38
EA-77-188	21	33	50	79	125	196	293	439	669	1046	1548
EA-77-250	34	62	93	147	232	364	532	814	1240	1938	----
EA-77-375	63	94	149	235	372	582	868	1302	1984	----	----
EA-77-500	50	141	212	335	532	829	1236	1855	----	----	----
EA-77-625	159	250	375	593	939	1470	2191	----	----	----	----

Ferrite POT Cores

Ferrite Material #77, 2000 Permeability



$$\text{Turns} = \sqrt{\frac{\text{desired L (mh)}}{A_L\ (\text{mh}/1000\,t)}} \times 1000$$



Physical Dimensions
(In millimeters)

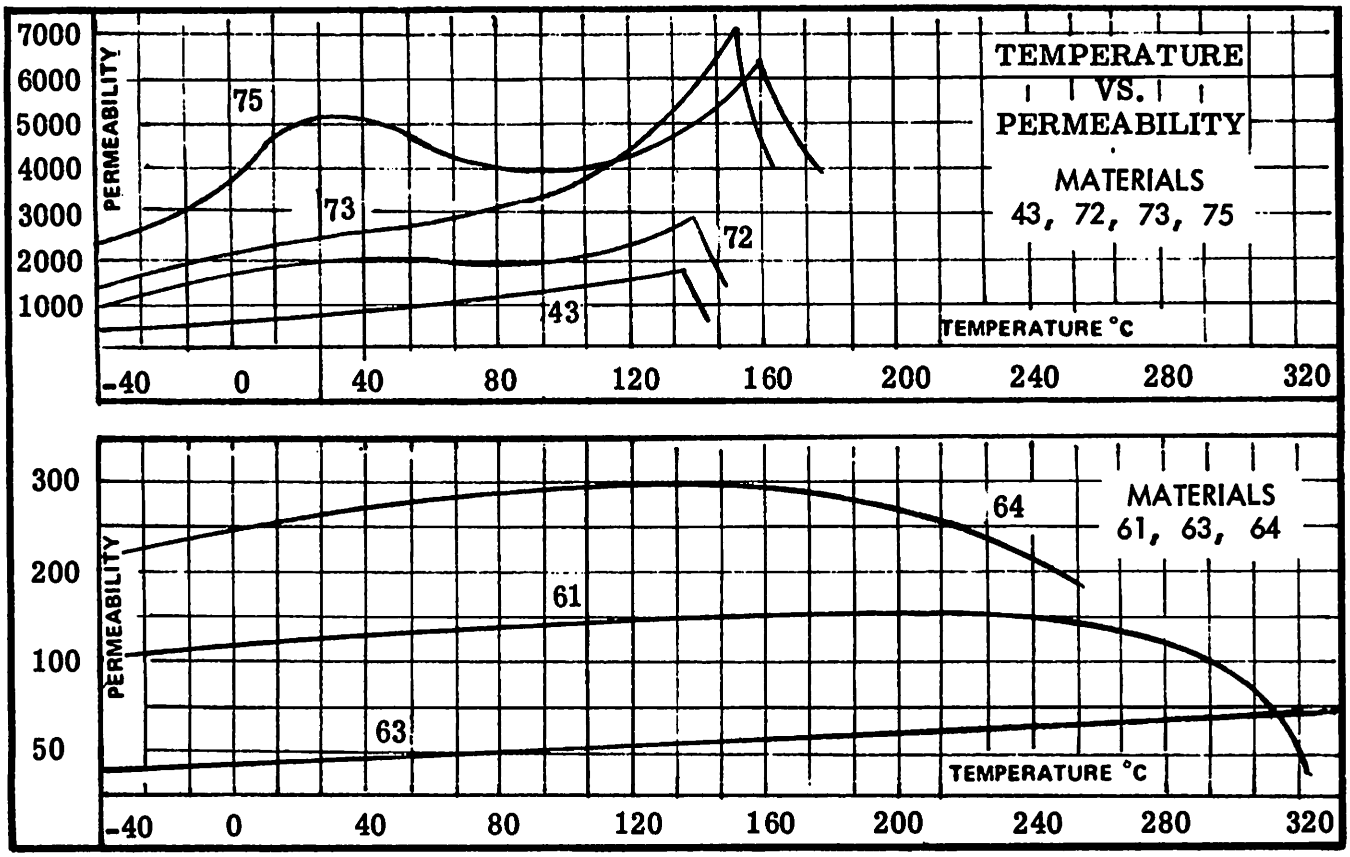
part mumber	A	B	C	D	E	F
PC-1107-77	11.10	9.20	4.60	2.10	3.21	2.27
PC-1408-77	14.05	11.80	5.90	3.10	4.18	2.90
PC-1811-77	18.00	15.25	7.45	3.10	5.27	3.70
PC-2213-77	21.60	18.70	9.25	4.55	6.70	4.70
PC-2616-77	25.50	21.60	11.30	5.55	8.05	5.60
PC-3019-77	30.00	25.40	13.30	5.55	9.40	6.60
PC-3622-77	35.60	30.40	15.90	5.55	10.85	7.40

Magnetic Dimensions

part number	A_e	l_e	V_e	A_e	Power
	mm^2	mm	mm^3	mh/1000-t	Based on 20 KHz
PC-1107-77	15.9	15.9	252	1420	Max 3 watts
PC-1408 77	25.0	20.0	500	1960	Max 5 watts
PC-1811-77	43.0	25.9	1120	2880	Max 10 watts
PC-2213-77	63.0	31.6	2000	3660	Max 20 watts
PC-2616-77	93.0	37.2	3460	4700	Max 50 watts
PC-3019-77	136.0	45.0	6100	5900	Max 70 watts
PC-3622-77	202.0	53.0	10600	7680	Max 90 watts

Note: Power ratings are conserative, based on 20 KHz. switching frequency.

Temperature Curves - Ferrite Materials

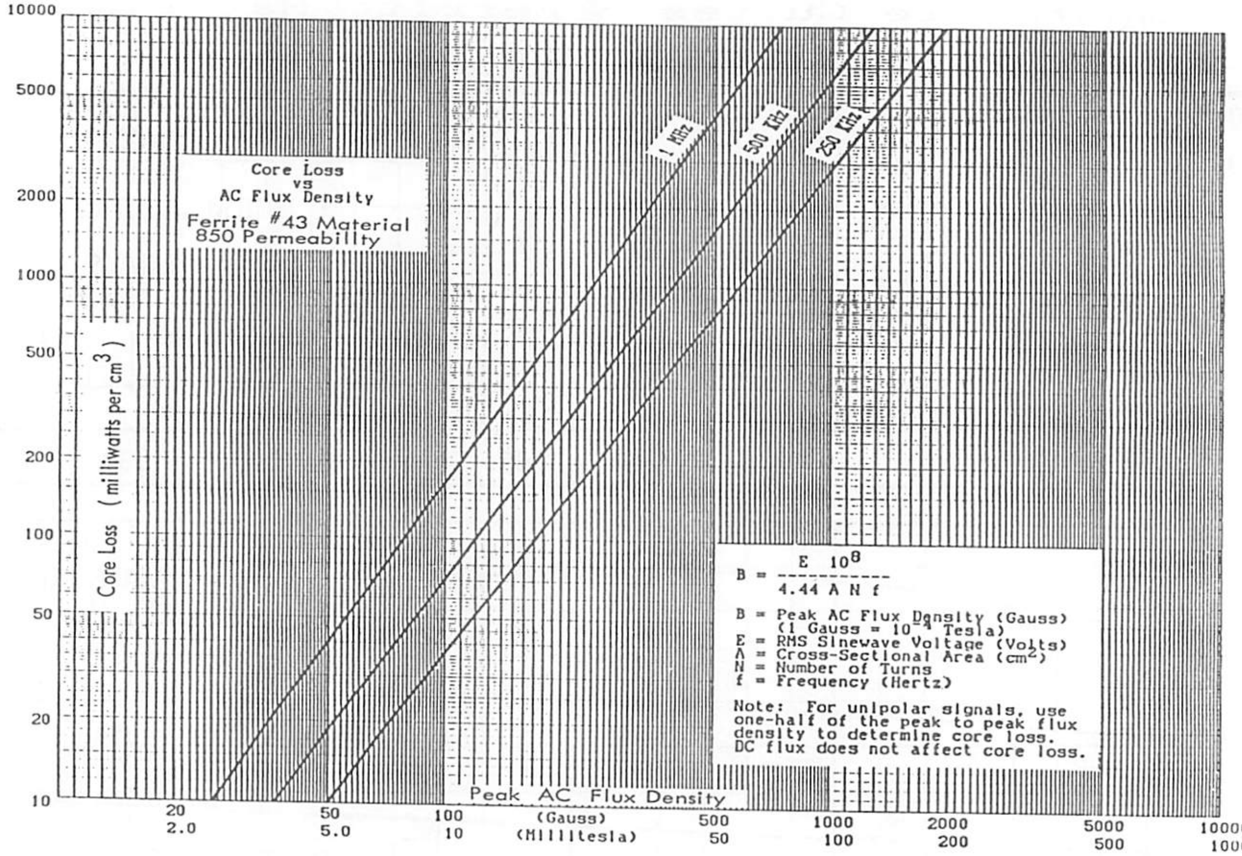


Ferrite core size vs. Wire turns

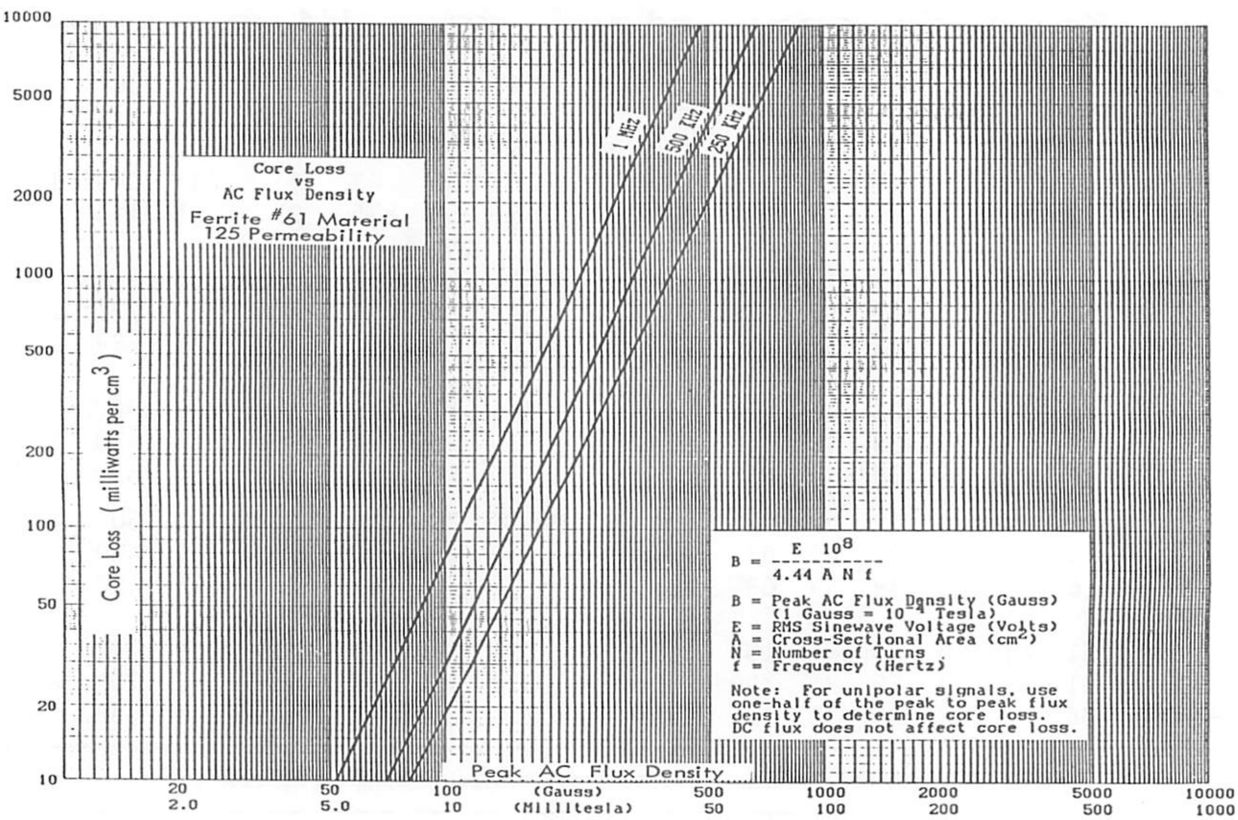
Awg wire> Core\/No.	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
FT-23	0	0	0	0	2	4	7	11	15	21	28	37	48	62	79	101
FT-37	0	0	2	4	7	11	15	21	28	36	48	61	79	100	127	161
FT-50	2	4	7	10	14	19	26	34	45	58	75	95	121	154	194	245
FT-50 -A	3	5	8	13	19	22	30	39	51	66	84	106	135	171	216	273
FT-50 -B	3	5	8	13	19	22	30	39	51	65	84	106	135	171	216	273
FT-82	9	13	18	22	32	41	53	69	88	112	143	180	228	288	362	456
FT-87A	10	14	19	25	34	43	56	72	92	118	150	188	239	302	374	478
FT-114	16	22	29	38	49	63	80	100	131	166	211	263	334	420	527	665
FT-114-A	16	22	29	38	49	63	80	100	131	166	211	263	334	420	527	665
FT-140	20	27	36	42	60	77	97	125	158	201	255	318	403	507	636	801
FT-150	16	22	29	38	49	63	80	100	131	166	211	263	334	420	527	665
FT-150-A	16	22	29	38	49	63	80	100	131	166	211	263	334	420	527	665
FT-193	31	41	53	68	86	109	139	176	223	282	357	445	562	707	886	1115
FT-193-A	31	41	53	68	86	109	139	176	223	282	357	445	562	707	886	1115
FT-240	36	46	60	77	98	123	156	198	250	317	400	499	631	793	993	1250

Approximate number of turns for full single layer winding on Ferrite Toroids.

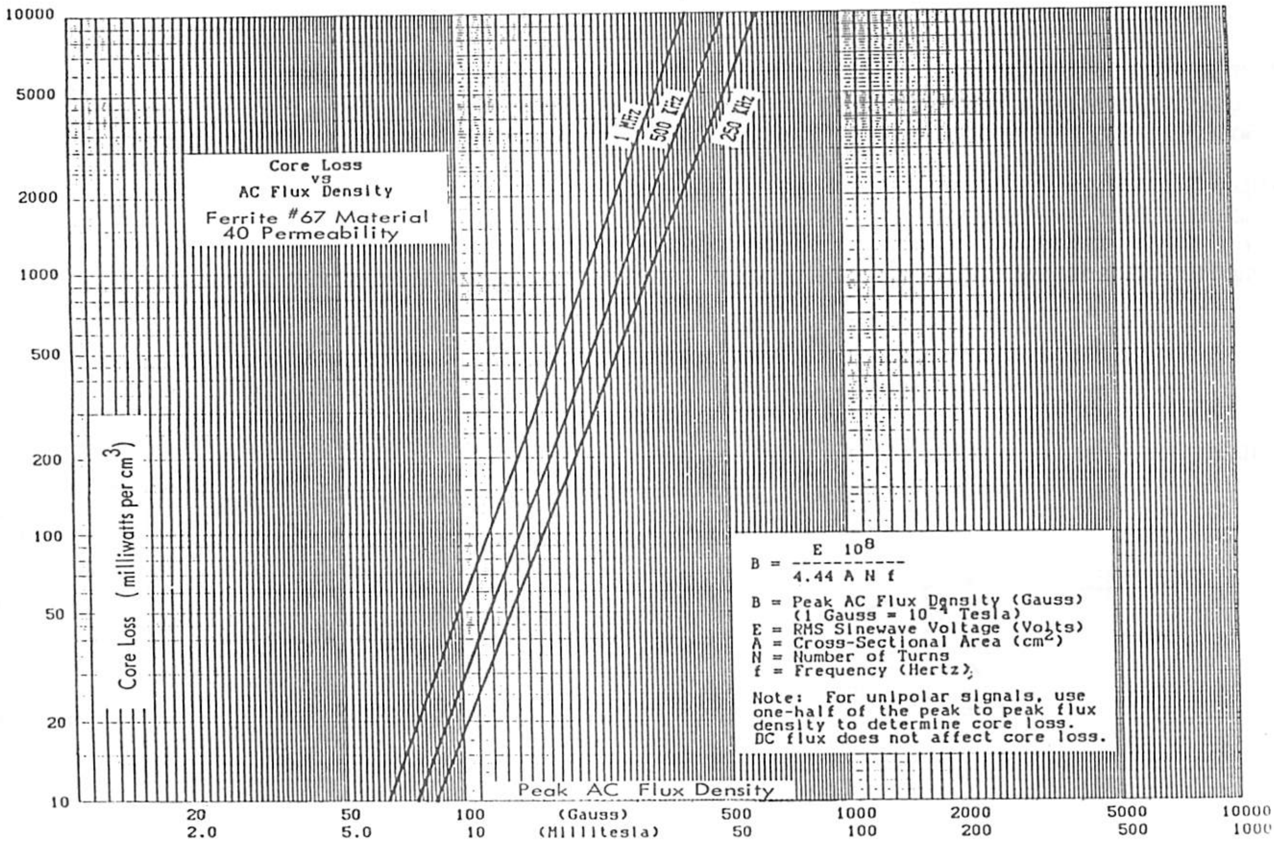
CORE LOSS vs. AC FLUX DENSITY
(Material #43)



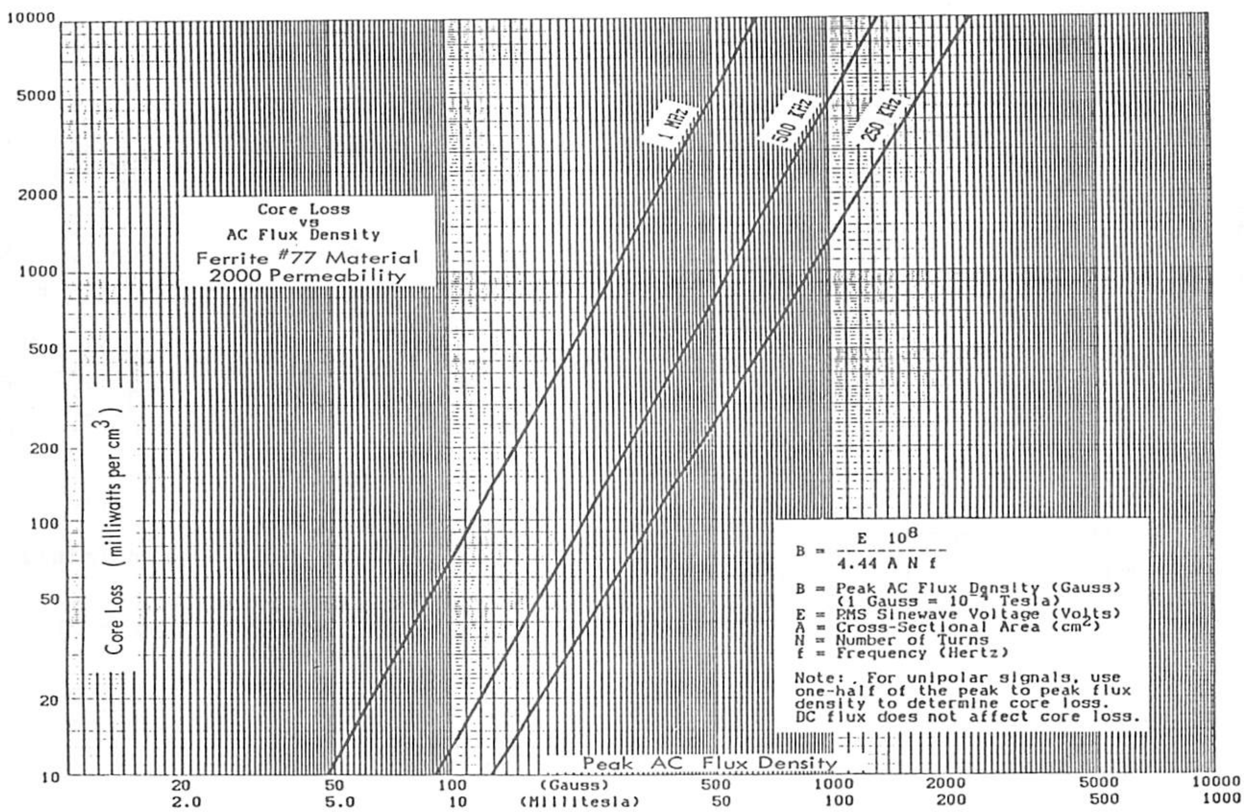
CORE LOSS vs. AC FLUX DENSITY
(Material #61)



CORE LOSS vs. AC FLUX DENSITY
(Material #67)



CORE LOSS vs. AC FLUX DENSITY
(Material #77)



FERRITE MATERIAL 33

Primary Characteristics
High permeability at reasonable cost
Good temperature stability

Applications
Inductors at medium frequency
LF and VLF antennas
Impeder rods and ignition coils

Available Core Shapes
Slugs and rods
Coil forms, threaded cores and sleeves

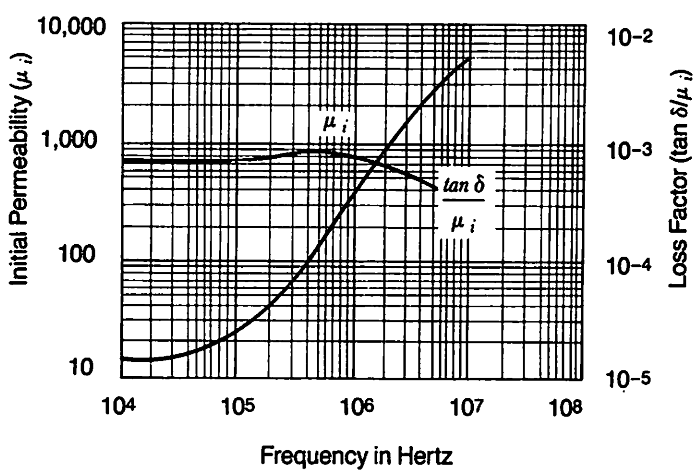


Figure 1: Initial Permeability and Loss Factor vs Frequency. Measured on a 1 inch OD toroid using a Hewlett-Packard 4275-A Multi-Frequency LCR Meter.

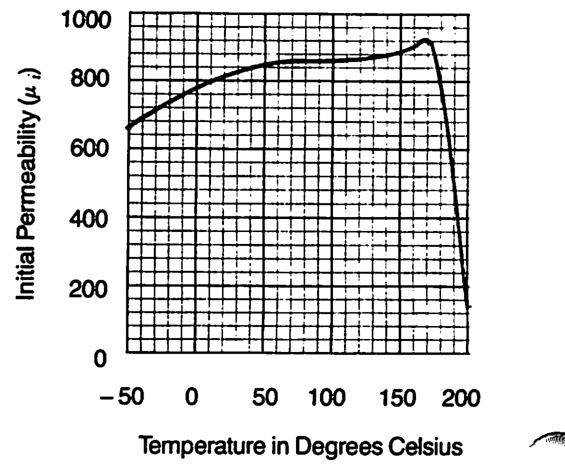


Figure 3: Initial Permeability vs Temperature including Curie point. Measured on a 1 inch OD toroid using a Hewlett-Packard 4275-A Multi-Frequency LCR Meter at 100 KHz.

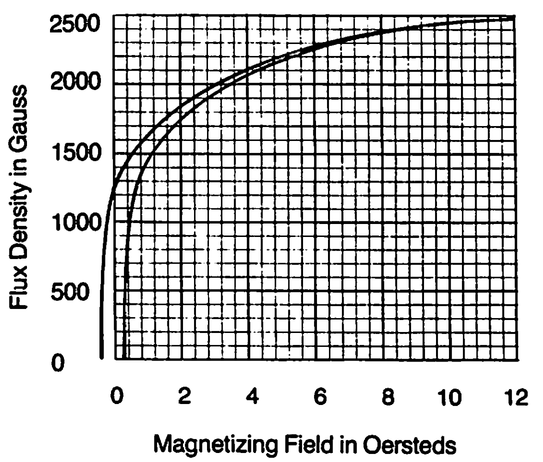


Figure 2: Hysteresis loop for a 1 inch OD toroid in 33 material.

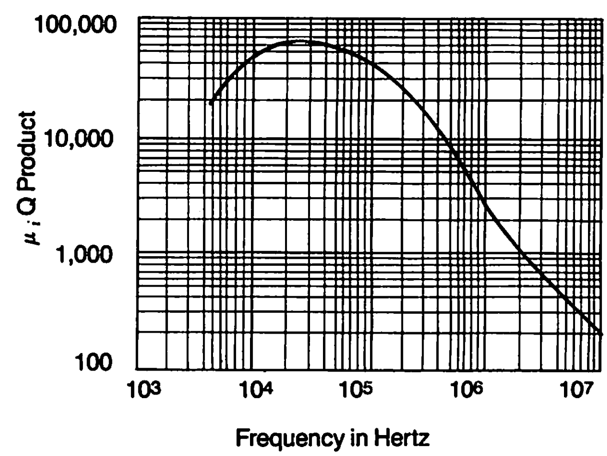


Figure 4: μ_i Q product (Initial Permeability × Quality Factor) vs Frequency for a 1 inch OD toroid in 33 material.

FERRITE MATERIAL 43

Primary Characteristics
High impedance
High resistivity

Applications
Optimum suppression of unwanted signals
above 40 MHz

Available Core Shapes
Shield Beads
Balun and broadband transformer cores
Special shapes for EMI suppression

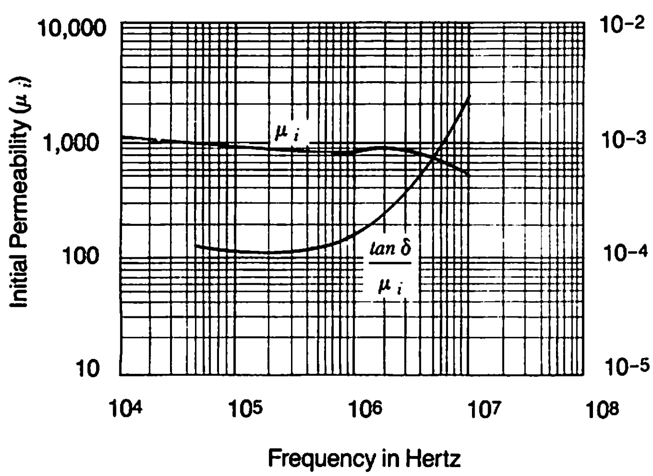


Figure 1: Initial Permeability and Loss Factor vs Frequency. Measured on a 1 inch OD toroid using a Hewlett-Packard 4275-A Multi-Frequency LCR Meter.

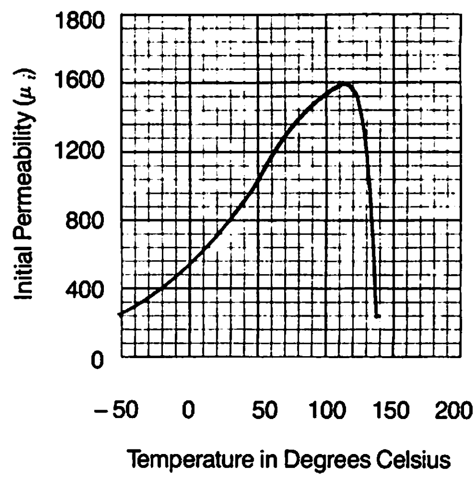


Figure 3: Initial Permeability vs Temperature including the Curie point. Measured on a 1 inch OD toroid using a Hewlett Packard 4275-A Multi-Frequency LCR Meter at 100 KHz.

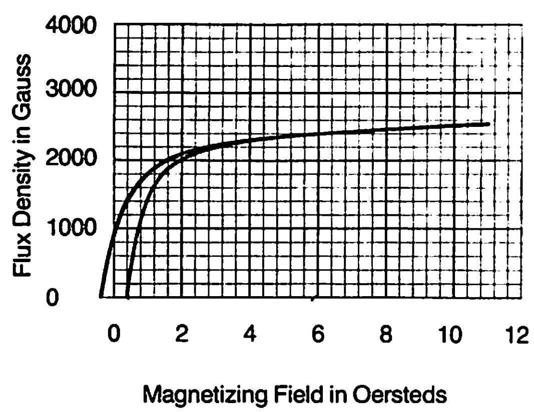


Figure 2: Hysteresis loop for a 1 inch OD toroid in 43 material.

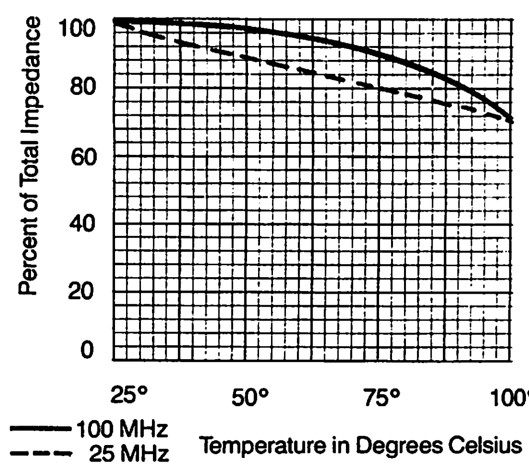


Figure 4: Percent of Total Impedance vs Temperature in Degrees Celsius for 43 material at frequencies of 25 and 100 MHz.

Primary Characteristics

High Q and high μ_i Q product
Useful tuned frequency range of 0.2 MHz to 10 MHz
High resistivity

Applications

Antenna and impeder rods
Inductors and choke coils
EMI suppression and broadband transformers

Available Core Shapes

Rods, slugs and toroids
Coil forms and threaded cores
Sleeves, bobbins, and balun and broadband cores
Shield beads

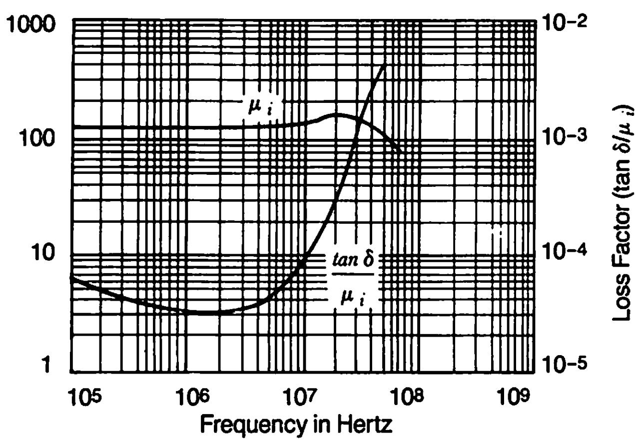


Figure 1: Initial Permeability and Loss Factor vs Frequency. Measured on a 1 inch OD toroid using a Hewlett-Packard 4275-A Multi-Frequency LCR Meter and a Hewlett-Packard 4191-A RF Impedance Analyzer.

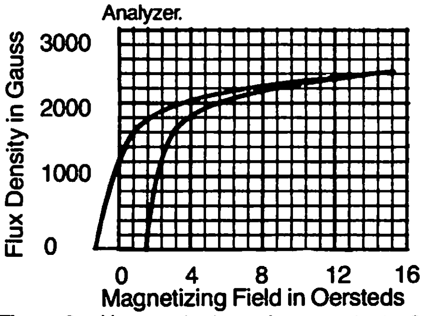


Figure 2: Hysteresis loop for a 1 inch OD toroid in 61 material.

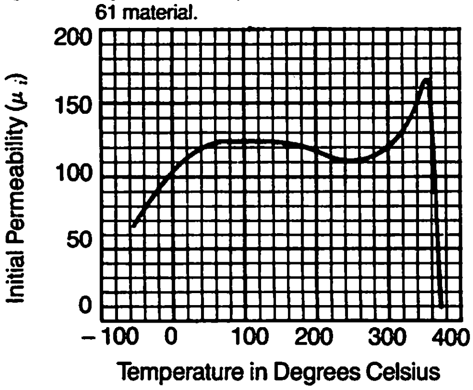


Figure 3: Initial Permeability vs Temperature including the Curie point. Measured on a 1 inch OD toroid using a Hewlett-Packard 4275-A Multi-Frequency LCR Meter at 100 KHz.

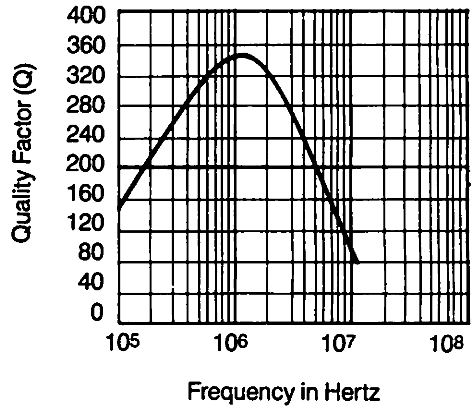


Figure 4: Quality Factor vs Frequency for a 1 inch OI in 65 material. Test equipment included a He Packard 4275-A Multi-Frequency LCR Meter and a Hewlett-Packard 4191-A RF Impedance Analyzer.

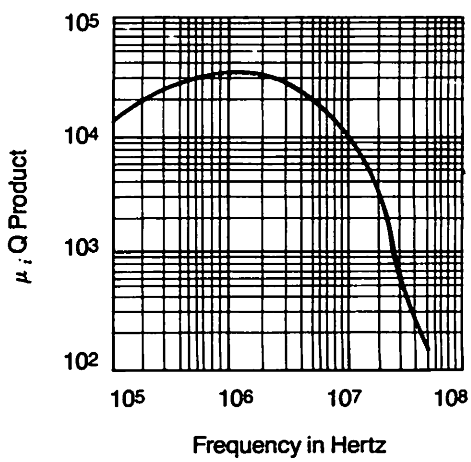


Figure 5: μ_i Q Product (Initial Permeability × Quality Factor) vs Frequency. Test equipment included a Hewlett-Packard 4275-A Multi-Frequency LCR Meter and a Hewlett-Packard 4191-A RF Impedance Analyzer.

Primary Characteristics

Useful tuned frequency range 15–25 MHz
High Q
High resistivity

Applications

High Q coils
High frequency antenna rods

Available Core Shapes

Antenna rods, threaded cores, toroids and slugs

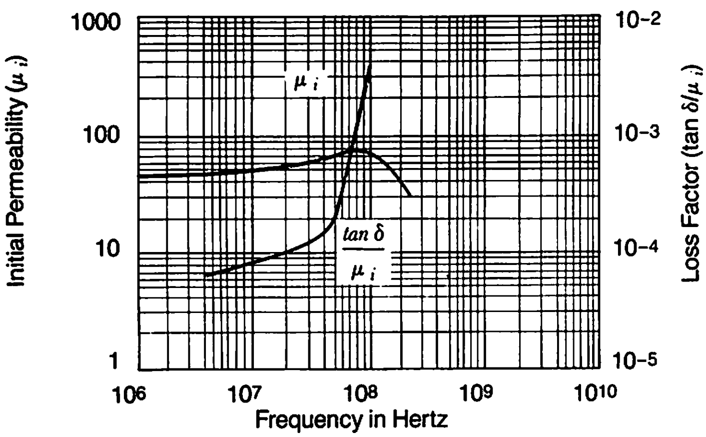


Figure 1: Initial Permeability and Loss Factor vs Frequency. Measured on a 1 inch OD toroid using a Hewlett-Packard 4275-A Multi-Frequency LCR Meter and a Hewlett-Packard 4191-A RF Impedance Analyzer.

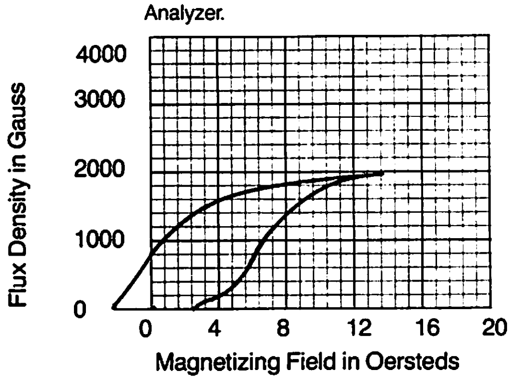


Figure 2: Hysteresis loop for a 1 inch OD toroid in 63 material.

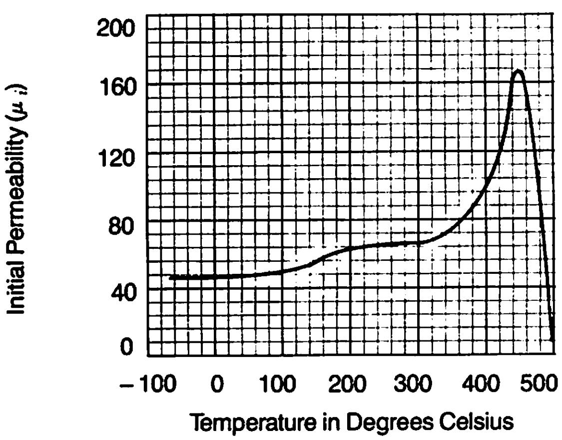


Figure 3: Initial Permeability vs Temperature including the Curie point. Measured on a .375 inch OD toroid using a Hewlett-Packard 4275-A Multi-Frequency LCR Meter at 100 KHz.

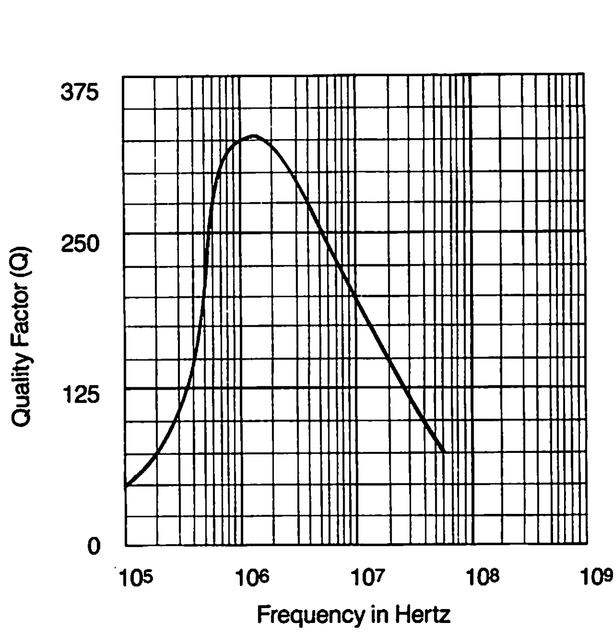


Figure 4: Quality Factor vs Frequency for a 1 inch OD toroid in 63 material. Test equipment included a Hewlett-Packard 4275-A Multi-Frequency LCR Meter and a Hewlett-Packard 4191-A RF Impedance Analyzer.

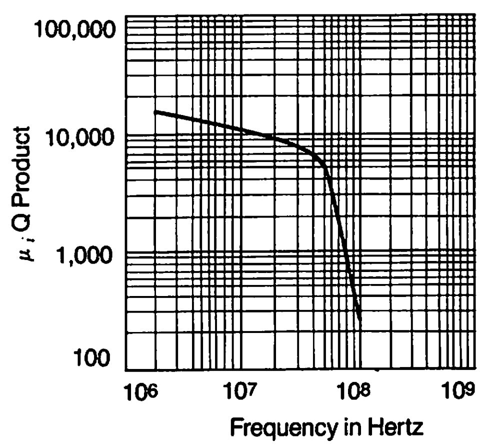


Figure 5: μ_i Q product (Initial Permeability × Quality Factor) vs Frequency for a 1 inch OD toroid in 63 material.

Primary Characteristics
High permeability at high frequencies
Useful tuned frequency range up to 4 MHz
Good shielding properties
Excellent temperature stability
High resistivity

Applications
Intermediate frequency range inductors
EMI Suppression
Broadband Transformers

Available Core Shapes
Shield beads, bobbins, rods and coil forms
Balun and broadband cores

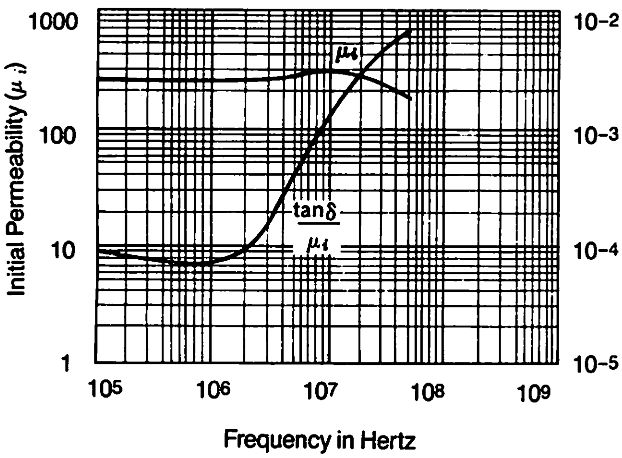


Figure 1: Initial Permeability and Loss Factor vs Frequency. Measured on a 1 inch OD toroid using a Hewlett-Packard 4275-A Multi-Frequency LCR Meter and a Hewlett-Packard 4191-A RF Impedance Analyzer.

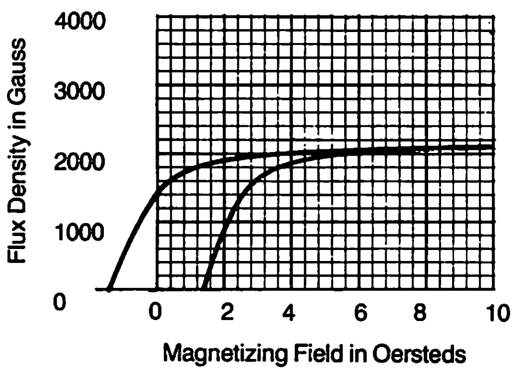


Figure 2: Hysteresis loop for a 1 inch OD toroid in 64 material.

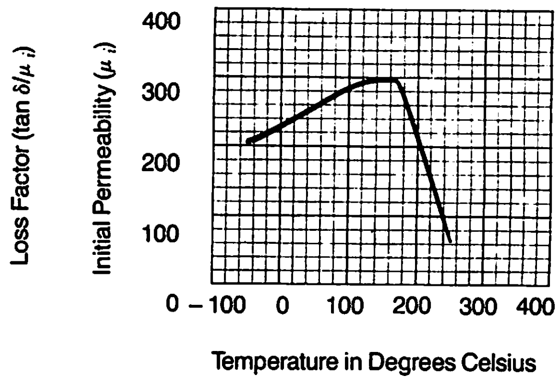


Figure 3: Initial Permeability vs Temperature including the Curie point. Measured on a 1 inch OD toroid using a Hewlett-Packard 4275-A Multi-Frequency LCR Meter at 100 KHz.

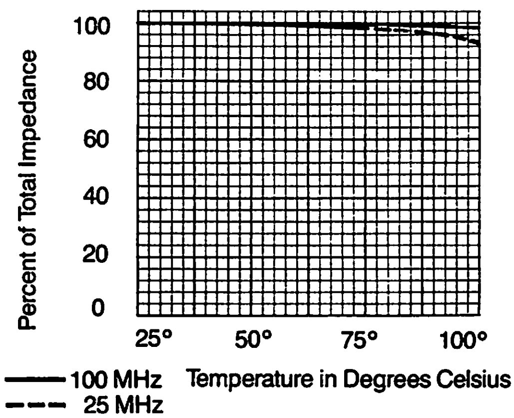


Figure 4: Percent of Total Impedance vs Temperature in Degrees Celsius for 64 material at frequencies of 25 and 100 MHz.

Primary Characteristics

High Q and high μ_i Q product
Useful tuned frequency range of 10 MHz to 80 MHz
– 55° Celcius to 300° Celcius
High resistivity

Applications

Communication equipment
Antennas and high frequency coils
Broadband and linear power transformers

Available Core Shapes

Toroids, rods, slugs, balun and broadband cores

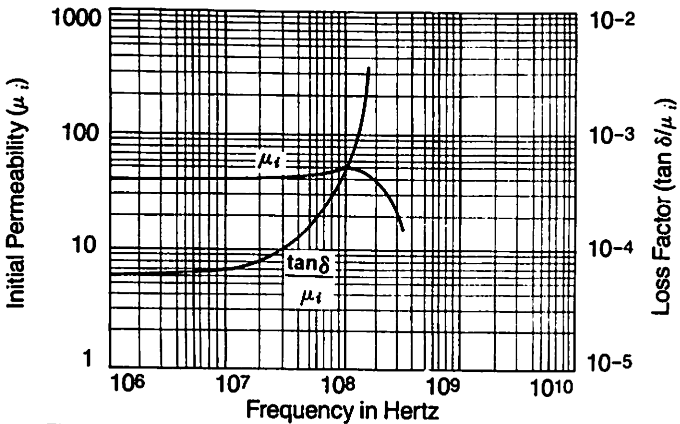


Figure 1: Initial Permeability and Loss Factor vs Frequency. Measured on a .375 inch OD toroid using a Hewlett-Packard 4275-A Multi-Frequency LCR Meter and a Hewlett-Packard 4191-A RF Impedance Analyzer.

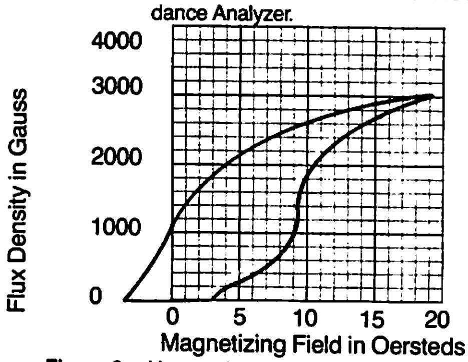


Figure 2: Hysteresis loop for 1 inch OD toroid in 67 material in unsaturated condition. If material becomes saturated it may exhibit a higher permeability and a lower Q value and hysteresis loop will assume a different shape.

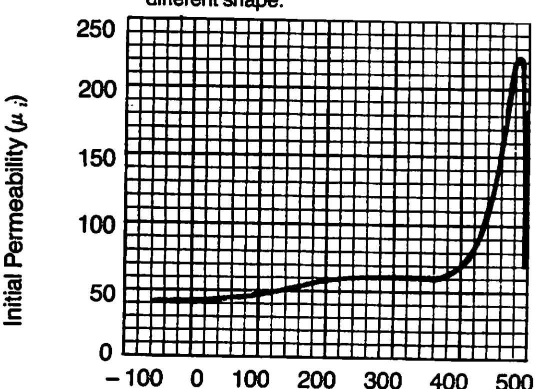


Figure 3: Initial Permeability vs Temperature including the Curie point. Measured on a .375 inch OD toroid using a Hewlett-Packard 4275-A Multi-Frequency LCR Meter at 100 KHz.

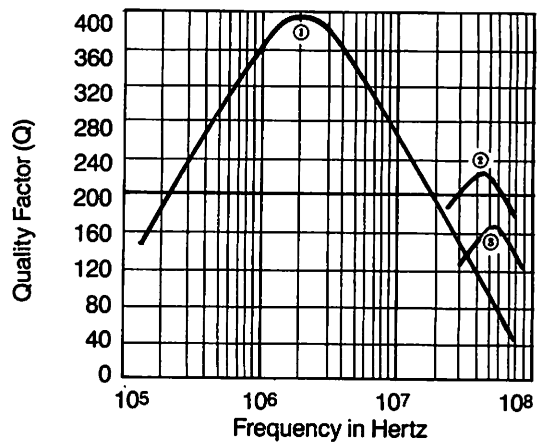


Figure 4: Quality Factor vs Frequency for a .375 inch OD toroid ① in 67 material. Test equipment included a Hewlett-Packard 4275-A Multi-Frequency LCR Meter and a Hewlett-Packard 4191-A RF Impedance Analyzer. The small curves were made using .184 inch OD × .375 inch long 32 threads per inch threaded cores and wound with ② 5 turns and ③ 2 turns of No. 22 solid copper wire.

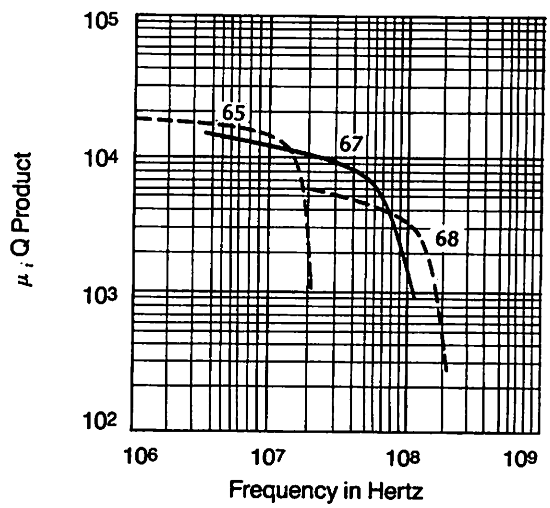


Figure 5: μ_i Q Product (Initial Permeability × Quality Factor) vs Frequency for 67 material comparing the optimum frequency range of this material to those of 65 and 68 materials.

Primary Characteristics

High Q and high μ_i Q product
Useful tuned frequency range of 50 MHz to 180 MHz
Excellent temperature stability from −55° Celcius to 300° Celcius
High resistivity

Applications

Communication equipment
Antennas and high frequency coils
Broadband and linear power transformers

Available Core Shapes

Toroids, rods, slugs, balun and broadband cores

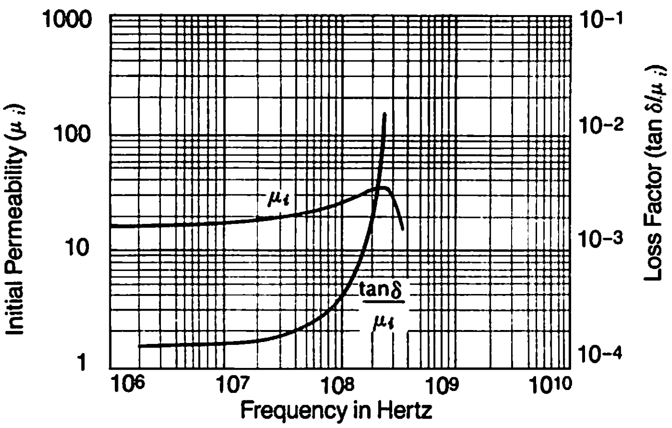


Figure 1: Initial Permeability and Loss Factor vs Frequency. Measured on a .375 inch OD toroid using a Hewlett-Packard 4275-A Multi-Frequency LCR Meter and a Hewlett-Packard 4191-A RF Impedance Analyzer.

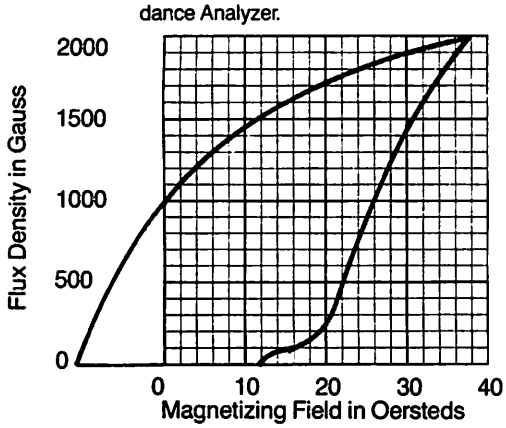


Figure 2: Hysteresis loop for 1 inch OD toroid in 68 material in unsaturated condition. If material becomes saturated it may exhibit a higher permeability and a lower Q value and the hysteresis loop will assume a different shape.

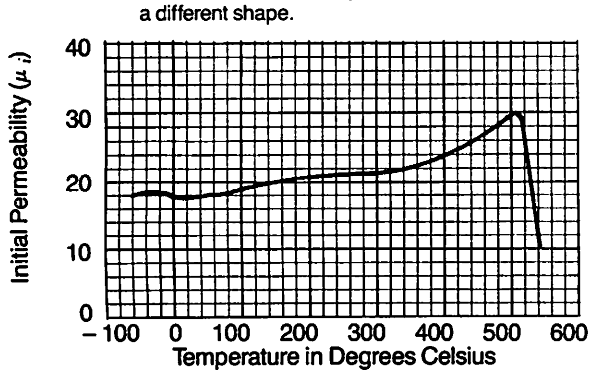


Figure 3: Initial Permeability vs Temperature including the Curie point. Measured on a .375 inch OD toroid using a Hewlett-Packard 4275-A Multi-Frequency LCR Meter at 100 KHz.

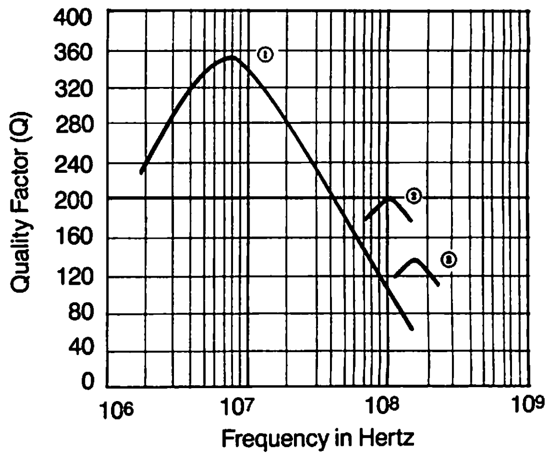


Figure 4: Quality Factor vs Frequency for a .375 inch OD toroid in ① 68 material. Test equipment included a Hewlett-Packard 4275-A Multi-Frequency LCR Meter and a Hewlett Packard 4191-A RF Impedance Analyzer. The small curves were made using .100 inch OD × .250 inch long 40 threads per inch threaded cores and wound with ② 4 turns and ③ 1 turn of No. 22 solid copper wire.

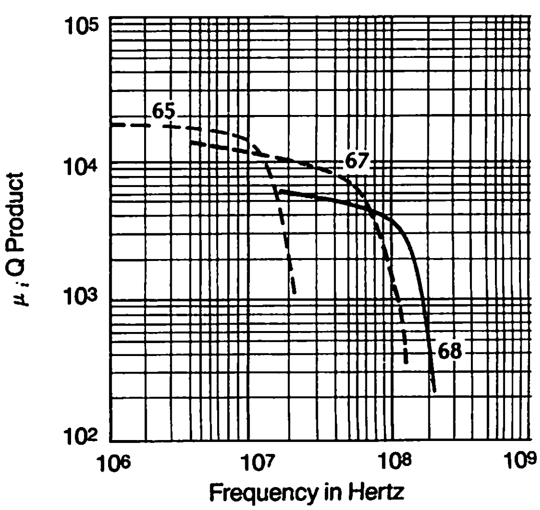


Figure 5: μ_i Q Product (Initial Permeability × Quality Factor) vs Frequency for 68 material comparing the optimum frequency range of this material to those of 65 and 67 materials.

FERRITE MATERIAL 73

Primary Characteristics
High impedance
Temperature stable impedance
High permeability

Applications
Optimum suppression of unwanted signals below 40 MHz
Broadband transformers

Available Core Shapes
Shield beads
Balun and broadband cores

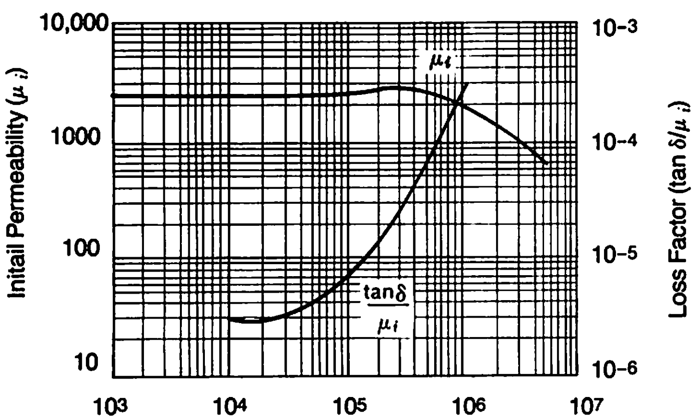


Figure 1: Initial Permeability and Loss Factor vs Frequency. Measured on a 1 inch OD toroid using a Hewlett-Packard 4275-A Multi-Frequency LCR Meter.

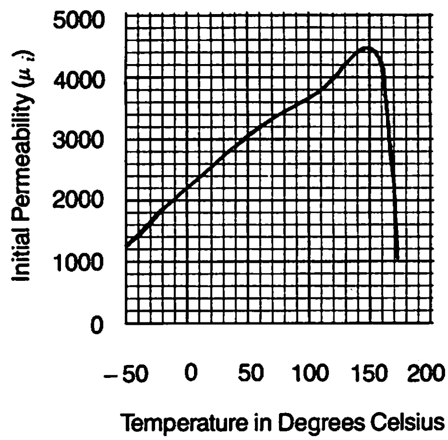


Figure 3: Initial Permeability vs Temperature including the Curie point. Measured on a 1 inch OD toroid using a Hewlett-Packard 4275-A Multi-Frequency LCR Meter at 100 KHz.

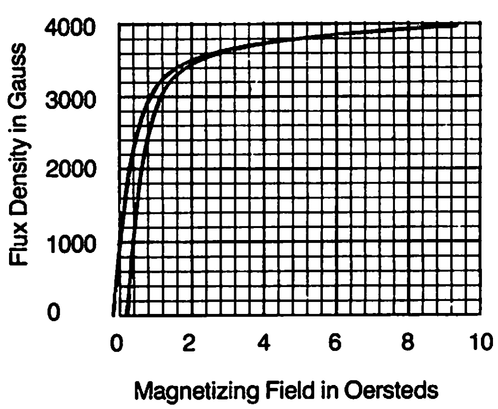


Figure 2: Hysteresis loop for a 1 inch OD toroid in 73 material.

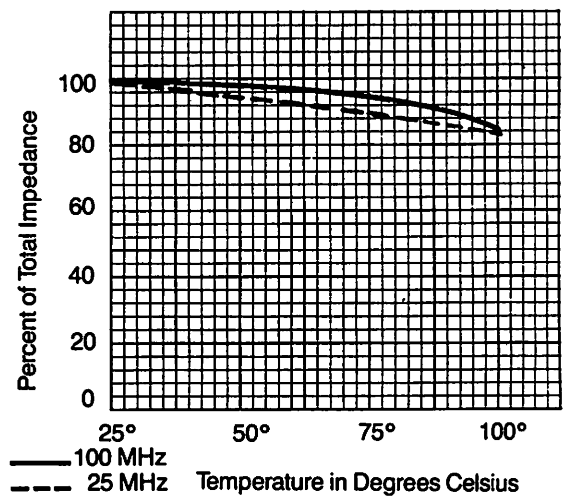


Figure 4: Percent of Total Impedance vs Temperature in Degrees Celsius for 73 material at frequencies of 25 and 100 MHz.

Primary Characteristics
High permeability
Low core loss

Applications
Low level power conversion equipment
Pulse transformers and linear transformers
Broadband transformers

Available Core Shapes
Toroids, E Cores and Potcores
Balun and Broadband Cores

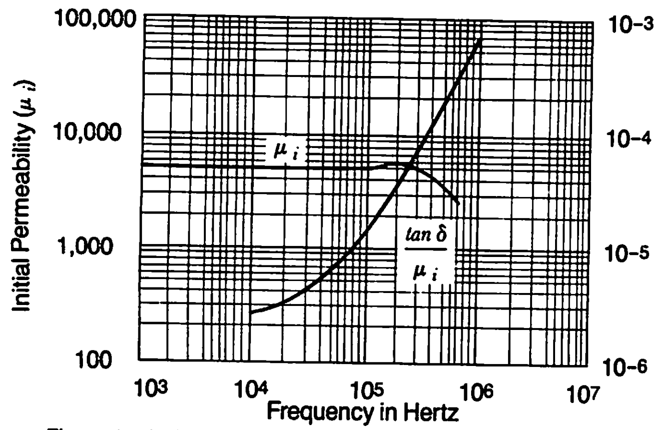


Figure 1: Initial Permeability and Loss Factor vs Frequency. Measured on a 1 inch OD toroid using a Hewlett-Packard 4275-A Multi-Frequency LCR Meter.

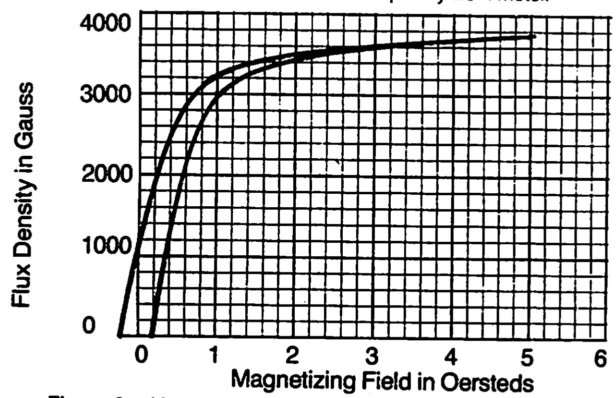


Figure 2: Hysteresis loop for a 1 inch OD toroid in 75 material.

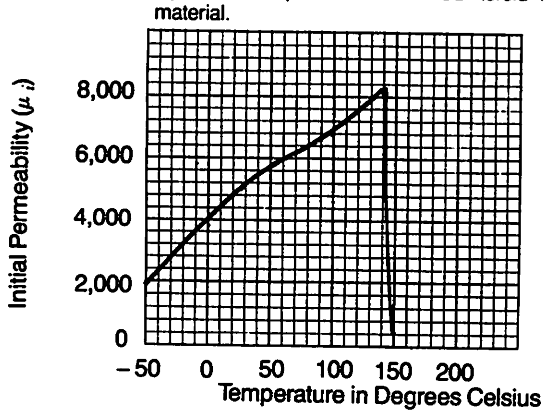


Figure 3: Initial Permeability vs Temperature including the Curie point. Measured on a 1 inch OD toroid using a Hewlett-Packard 4275-A Multi-Frequency LCR Meter at 100 KHz.

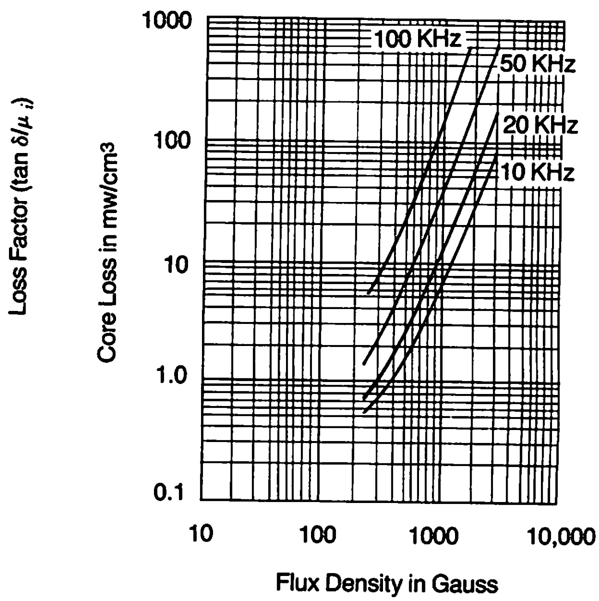


Figure 4: Core Loss vs Flux Density at several frequencies and at room temperature. Test sample was a 1 inch OD toroid and test equipment was a Clark Hess Model 255 VAW Meter.

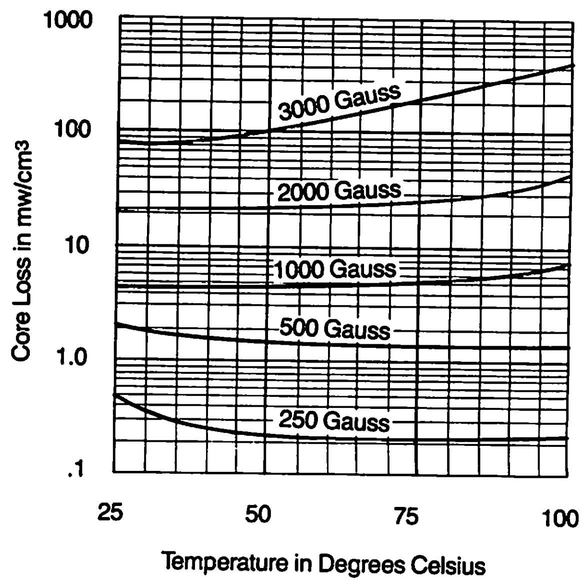


Figure 5: Core Loss vs Temperature at several flux densities and at 10 KHz. Test sample was a 1 inch OD toroid and test equipment was a Clark Hess Model 255 VAW Meter.

Primary Characteristics

High Saturation flux density at high temperatures
High permeability at high flux density
Low core loss

Applications

Pin cushion correction transformers
Power conversion transformers
Power Filters
Ignition Coils
EMI Suppression and Broadband Transformers

Available Core Shapes

E Cores, pot cores, U cores, I cores, slugs
Toroids, bobbins and threaded cores
Shield Beads and Broadband Transformer Cores
EP Cores, PQ Cores and ETD Cores

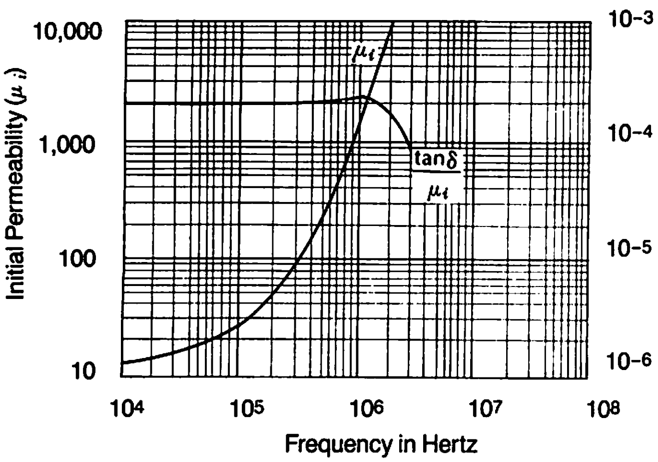


Figure 1: Initial Permeability and Loss Factor vs Frequency. Measured on a 1 inch OD toroid using a Hewlett-Packard 4275-A Multi-Frequency LCR Meter.

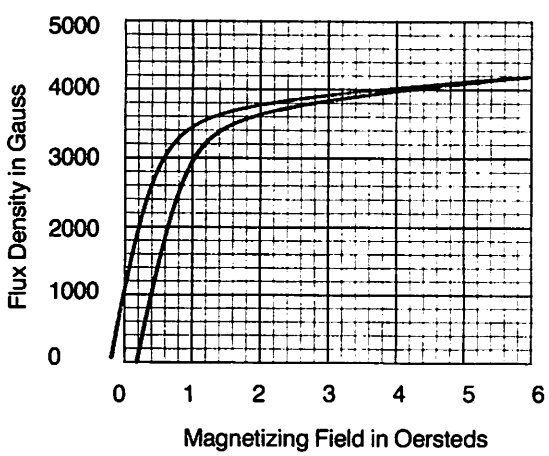


Figure 2: Hysteresis loop for a 1 inch OD toroid in 77 material.

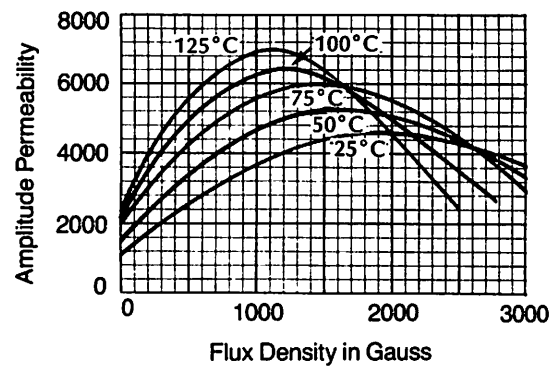


Figure 3: Amplitude Permeability vs Flux Density at various temperatures at 10 KHz. Test sample was a 1 inch OD toroid and test equipment included a signal generator, an amplifier, an integrator and an oscilloscope. Permeability was calculated as follows:

$$\mu_a = \frac{B_{max}}{H_{max}}$$

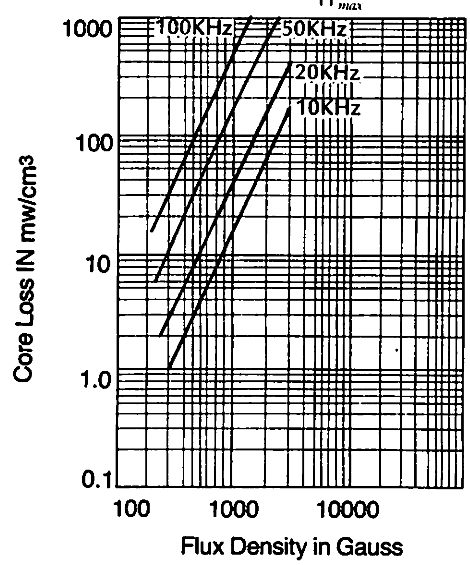


Figure 4: Core Loss vs. Flux Density at several frequencies and at room temperature. Test sample was a 1 inch OD toroid and test equipment was a Clark Hess Model 255 VAW Meter.

TEMP.	−25°C	0°C	23°C	50°C	75°C	100°C	125°C
B_s	4950	4725	4600	4150	3825	3450	3050
B_r	1800	1450	1150	1000	875	800	750
H_c	.30	.25	.22	.20	.18	.16	.13

Table 1: Typical values of hysteresis loop parameters at various temperatures. All measurements made at H_{max} = 10 Oersteds.

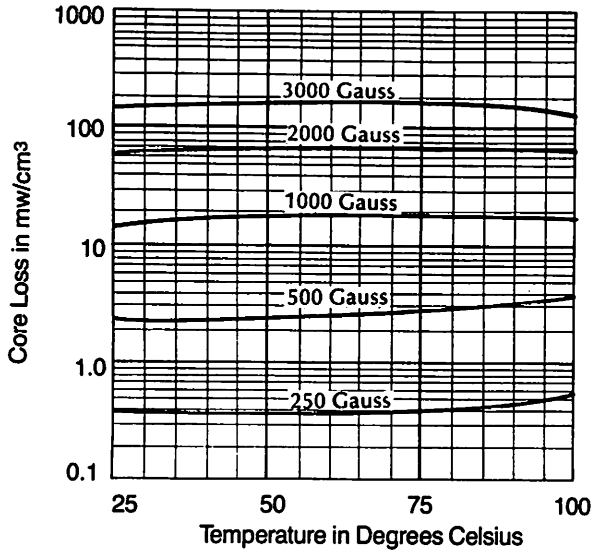


Figure 5: Core Loss vs Temperature at several flux densities and at 10 KHz. Test sample was a 1 inch OD toroid and test equipment was a Clark Hess Model 255 VAW Meter.

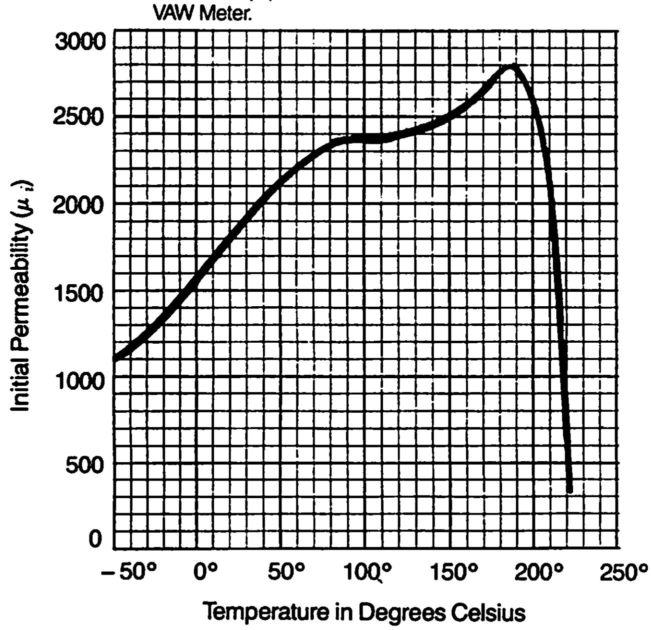


Figure 6: Initial Permeability vs Temperature including the Curie point. Measured on a 1 inch OD toroid using a Hewlett Packard 4275-A Multi-Frequency LCR Meter.

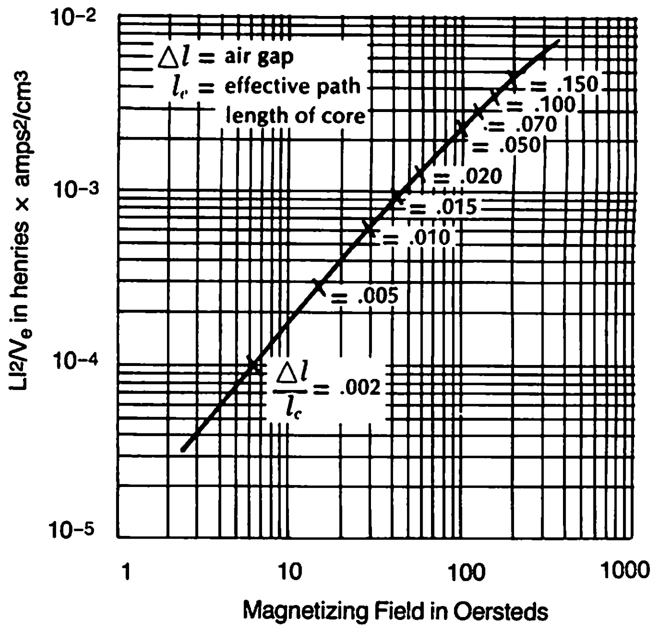


Figure 7: Hanna Curve which permits calculation of inductance of gapped cores with dc current flowing in the coil. For further information concerning the use of the Hanna Curve to derive the optimum gap for ferrite cores, see the section "The Effect of Direct Current on the Inductance of a Ferrite Core."

FERRITE MATERIAL 83

Primary Characteristics

Square Hysteresis loop over a wide temperature range

Squareness ratio $\left\{ \frac{B_r}{B_s} \times 100 \right\} \geq 82\%$ at 23° C

High Curie temperature

Applications

Converters and inverters
Ferro-resonant transformers for regulated power supplies
Power conversion equipment

Available Cores Shapes

Toroids

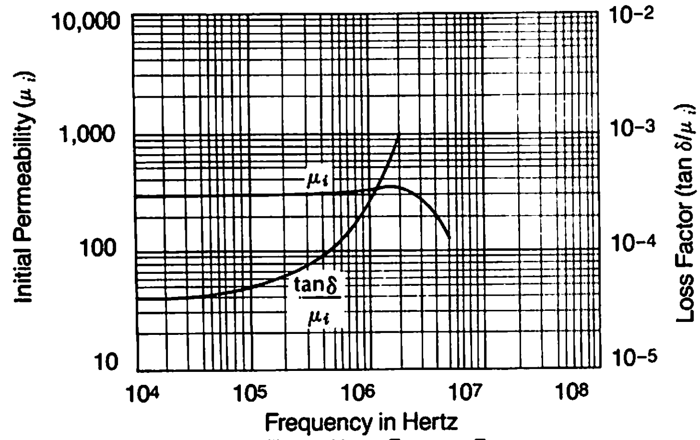


Figure 1: Initial Permeability and Loss Factor vs Frequency. Measured on a 1 inch OD toroid using a Hewlett-Packard 4275-A Multi-Frequency LCR Meter.

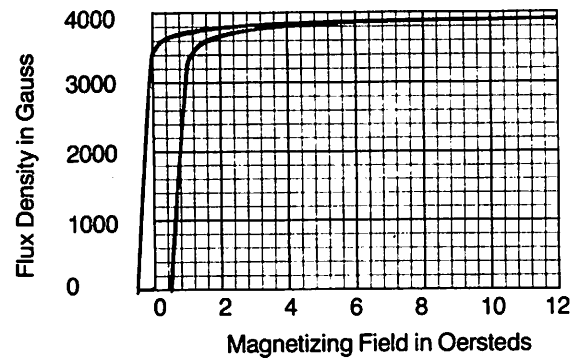


Figure 2: Hysteresis loop for a 1 inch OD toroid in 83 material.

Temp.	$^*B_s$	$\frac{B_r}{B_s} \times 100$	H_c
−25°C	4050	88%	.56
0	3900	88	.52
23	3850	87	.45
50	3575	86	.40
75	3375	84	.34
100	3275	82	.32
125	3050	80	.30

$^*B_S$ measured at H_{max} = 10 oersteds

Figure 3: Typical values of hysteresis loop parameters at various temperatures.

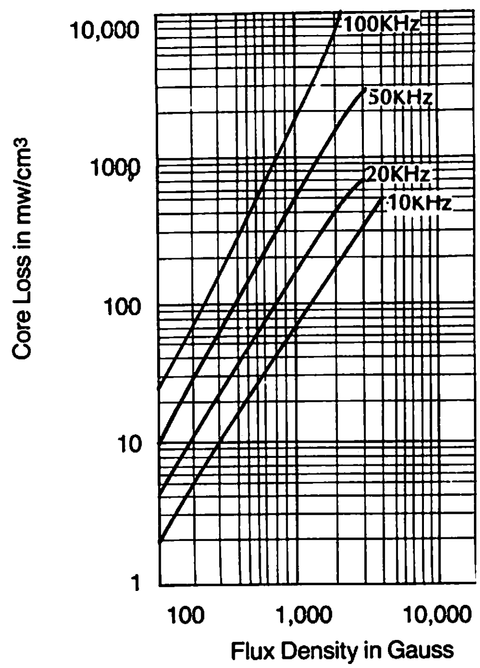


Figure 4: Core Loss vs Flux Density at several frequencies and at room temperature. Test sample was a 1 inch OD toroid and test equipment was a Clark Hess Model 255 VAW Meter.

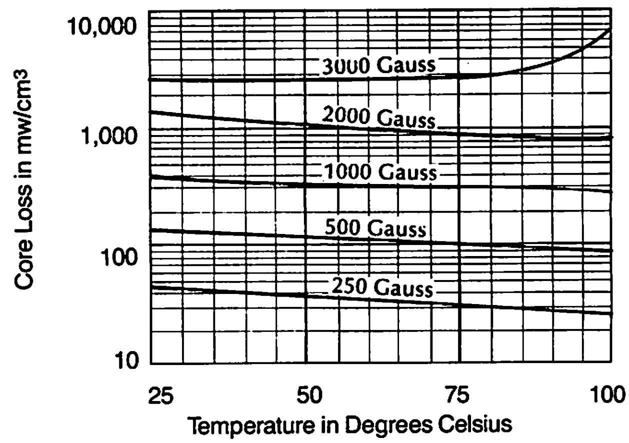


Figure 5: Core Loss vs Temperature at several flux densities and at 50 KHz. Test sample was a 1 inch OD toroid and test equipment was a Clark Hess Model 255 VAW Meter.

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September 1988

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